SOIL SPECIALIST REPORT

Somes Bar Integrated Fire Management Project [EA]

Six Rivers and Klamath National Forests

Orleans and Ukonom Ranger Districts

Humboldt and Siskiyou Counties, CA

December 7, 2017

Typical Goldridge soil in a plantation, unit 2328 in Rogers Creek focal area.

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Executive Summary (acronyms spelled out below in report)

The project areas were all field reviewed for soil resources assessment during field seasons of 2015 (Hagerty) and 2016 (Hagerty and Young), with emphasis given to units with proposed mechanical treatments and/or previous management using mechanical harvest methods.

Soil management objectives with this project are:

1) Keep soil in place: minimize erosion and sedimentation by adhering to BMPs and maintaining effective soil cover at or above minimum levels specified herein;
2) Minimize and/or mitigate secondary soil quality impacts (compaction, displacement, severe burning) by applying PDFs specified herein, which mainly aim to limit severity and aerial extent of such impacts;
3) Monitor project activities as they occur, particularly mechanical treatments and prescribed burning, to ensure acceptable soil cover levels are maintained.

Pre-burn thinning and fuels treatment activities are conventional, and we know from experience how to successfully limit soil impacts associated with these activities. The *extent* of prescribed burning is the greater risk for soils here, and care will need to be taken through burn plan prescription provisions to explicitly protect minimum levels of soil cover.

With soil protections specified herein effectively applied during staged implementation, soil impacts are expected to be minimal and acceptable, meaning in compliance with the Forests' LRMPs and complying with the intent of NFMA (1976) to maintain long-term soil productivity.

Project-associated soil impacts are preferred to No Action, as erosion impacts following a severe wildfire may reasonably be assumed the single greatest threat to long-term soil productivity. Fire has a natural and historic role in these landscapes, but is out of balance given present fuels conditions as a result of long-term fire suppression. Fire will return to these landscapes as a matter of *when*, not *if*, and soil resources will be best conserved by preparing and re-balancing fuels distributions within this landscape.

The author has 18 years' experience as a Soil Scientist with the Forest Service, with PSW Research Station for six years, and for the last ten years the R5 Northern CA Zone Soil Scientist in a shared-services position covering 8 National Forests. Previously a private consulting forester in the '90s. The author has experience designing, implementing, and monitoring a wide variety of forestry and vegetation management projects in the west-coast states and Alaska, with specialties in soils, geology, silviculture, and logging systems.

1 INTRODUCTION

This report provides an analysis of the effects of the Somes Bar Integrated Fire Management Project on short-term and long-term soil quality and productivity in the project focal areas. This project is unusual in its truly collaborative nature with close Karuk Tribe involvement throughout project concept and development, and from a soils perspective because some form of prescribed burning is proposed in essentially 100% of the focal areas.

The report describes the soils in the project area, provides an assessment of current soil conditions, and analyzes the potential effects that treatments under the proposed action alternative are expected to have on the soil resource. Operational restrictions and mitigations that would help minimize adverse effects on soil quality and productivity are included in the form of Project Design Features (PDFs).

This report includes:

- The regulatory framework and applicable standards and guidelines that were used to evaluate soil condition and potential impacts of proposed treatments;
- A description of the methods used to assess the effects of the project on soils;
- A description of the affected environment, and assessment of the current condition of soils, including effects of past management activities;
- An assessment of the direct, indirect, and cumulative effects of the proposed action on the soil resource;
- Appendices, including soil and slope maps, an activity unit by soil map unit crosswalk table (used to identify units with "sensitive" soils for priority attention in field review), and erosion hazard rating (EHR) calculations.

The Orleans Ranger District of the Six Rivers National Forest is proposing to treat administrative lands within the project area in order to improve native food security, treat fuels buildups from an era of fire suppression, and restore fire resiliency to the landscape. Contributing to rural economic health and employment opportunity is also an expected socioeconomic benefit. The project is located on the Orleans and Ukonom Ranger Districts of the Six Rivers and Klamath National Forests, respectively. Most of the lands involved are Ukonom, here *administered* by the Six Rivers NF, but Klamath LRMP provisions apply.

For a detailed description of the alternatives considered in detail, specific actions, and a complete listing of multi-disciplinary Project Design Features (PDFs), see the Somes Bar Project EA, Chapter 2; these details are not repeated here. Two Alternatives are analyzed in this report: Alternative 1 – No Action, and Alternative 2 – the Proposed Action alternative.

To briefly summarize here, the project proposes to use a combination of silvicultural prescriptions and fuels treatments to transition the project area toward meeting the stated purpose and need for the project. The silvicultural prescriptions include commercial and non-commercial thinning harvests, and mechanical (tractor), cable, and manual methods. Fuels treatments include broadcast and pile burning after intermediate density and understory treatments, or without intermediate treatment where stand and understory conditions permit. Other connected actions associated with this project include segments of temporary road construction and some new landings for logging operations, as well as reutilization and proper decommissioning of some legacy temporary roads where identified as appropriate and feasible.

2 REGULATORY FRAMEWORK

Forest Service management actions relative to Forest Plan implementation are subject to various applicable laws, regulations, policy, guidance, and management direction; these collectively determine the overall objectives and standards and guidelines applied to FS management activities in a typical interdisciplinary resource management setting. Elements relevant specifically to the soil resource are described here.

2.1 LEGISLATION AND POLICY DIRECTIVES

2.1.1 Multiple-Use and Sustained-Yield Act (MUSYA) of 1960

The Act established principles of multiple-use of renewable surface resources of the National Forests, and sustained-yield, each/both of which shall be managed without impairment of the productivity of the land [not defined].

2.1.2 National Environmental Policy Act (NEPA) of 1970

The Act directs all federal agencies to consider and report the potential environmental impacts of proposed federal actions, and established the Council on Environmental Quality (CEQ). This was the first Act to stipulate federal agencies shall initiate and utilize ecological information in the planning and development of resource-oriented projects.

Federal actions significantly affecting the quality of the human environment will include a statement on (ii) adverse environmental effects which cannot be avoided, (iii) alternatives to the proposed action where unresolved conflicts are involved, (iv) the relationship between local short-term uses and the maintenance or enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

2.1.3 Forest and Rangeland Renewable Resources Planning Act (RRPA) of 1974

The primary purpose of the Act is to protect, develop, and enhance the productivity and other values of NFS lands. References MUSYA several times, adding that management will not produce *substantial and permanent* impairment of the land [not defined].

This was the first Act to name soil as a fundamental resource: recognize the fundamental need to protect and, where appropriate, improve the quality of soil, water, and air resources; provides for obtaining soil inventory data and mapping; timber will be harvested only where soil, slope, or other watershed conditions will not be irreversibly damaged; cuts are carried out in a manner consistent with protection of soil and watershed resources.

The Act also provides for research and monitoring of management system effects to the end that they will not produce substantial and permanent impairment of the land [not defined].

2.1.4 National Forest Management Act (NFMA) of 1976

NFMA is the primary statute governing the administration of National Forest System lands. The Act requires the maintenance of productivity of the land and the protection and, where appropriate, improvement of the quality of the soil and water resources. The Act specifies that substantial and permanent impairment of productivity [not defined] must be avoided. Further, activities must be monitored to ensure that productivity is protected. This law led to subsequent regulation and policy to execute the law at various levels of management.

2.1.5 Forest Service Washington Office (WO) Manual 2550 – Soil Management (Nov. 2010)

The FSM provides a national directive to maintain or restore soil quality on NFS lands, and establishes the management framework for sustaining soil quality and hydrologic function while providing goods and ecosystem services outlined in Forest and Grassland land management plans. The FSM defines soil productivity and soil quality, and describes soil functions that may be used in evaluating soil quality.

The FSM outlines programmatic requirements for assessments, analyses, and monitoring pursuant to management activities, and outlines general requirements that Standards and Guidelines be developed and implemented at Regional and Forest levels.

Standards and guidelines are intended to prevent substantial and permanent damage or degradation that affects inherent ecosystem processes. Substantial and permanent soil impairment is defined as detrimental changes in soil properties (physical, chemical, biological) that result in the loss of the inherent ecological capacity or hydrologic function of the soil resource, over the mid-term (*substantial*, beyond the duration of the project) to long-term (*permanent*, beyond a land management planning period), respectively.

2.1.6 Forest Service Region 5 FSM Supplement – Soil Quality Mgmt (R5-2500-2017-1)

Soil management direction is applied to lands dedicated to growing vegetation; it is not applied to areas dedicated to other uses, such as roads, trails, administrative and recreation sites, etc. The Supplement specifies 3 key soil functions to be used in R5 for assessment and analysis of soil quality: support for plant growth function, soil hydrologic function, and filtering-buffering function. Indicators and desired conditions for indicators are outlined for each soil function. Soil condition is rated as good, fair, or poor for each indicator relative to the desired condition. This approach is intended to help determine the status and trend of soil management, determine whether ecosystem health and long-term soil productivity is being maintained, and better determine needs and priorities for restoration activities.

The R5 Soil Quality Management Supplement (SQMS) uses the following indicators to evaluate management effects on key soil functions:

<u>Support for Plant Growth Function [soil productivity]</u>

- Soil stability – maintain adequate soil cover to prevent accelerated erosion.
- Surface organic matter – maintain adequate soil cover to provide for support of soil biology and nutrient cycling [maintain soil *inputs* of organic matter].
- Soil Organic Matter (SOM) – maintain the topsoil in place [avoid excessive displacement]. An area is considered displaced if more than one-half or 4 inches (whichever is less) is removed from a contiguous area larger than 100 square feet.
- Soil strength – maintain a favorable rooting environment [avoid excessive compaction].
- Soil moisture regime – maintain the inherent soil moisture regime, especially in wet meadows and fens.

Soil Hydrologic Function

- Soil stability – maintain adequate soil cover to prevent accelerated erosion.
- Soil structure and macro-porosity – maintain sufficient structure and macro-porosity in most of the area to provide for water infiltration and permeability [avoid excessive compaction, displacement, puddling, or severe burning].

Filtering-Buffering Function

- For projects involving chemical or nutrient applications to the soil, an analysis is completed to maintain soil chemistry and capacity to filter and buffer foreign compounds.

Another provision of the Supplement is considerable direction on the *process* of conducting assessments and analyses. The activity area is no longer defined necessarily as individual harvest units, and it is not considered always necessary to field review each and every unit. For large projects (such as this) a prioritization approach is recommended, utilizing various soil risk ratings and interpretations to focus field review on areas with the higher risks to soils:

- "Assessments can be conducted on individual treatment units, entire activity areas, or specially designated land management areas. The area bounded by the assessment would be described or defined."
- "Existing soil condition must be determined in the field, and field work needs to be focused where risks are greatest. Generally it is not feasible or practical to field visit all proposed management areas, so priority sites must be chosen. Highest priority areas to field review are where soil condition may have been adversely affected by past management, and where proposed activities have the greatest potential to cause adverse effects to soil functions."

Various types of soil disturbance (compaction, displacement, severe burning, etc.) may affect key soil functions in different ways on different soils and sites. Both *degree* and *extent* of disturbance are important considerations that must be evaluated together to assess potential adverse impacts on soil functions for the activity area. Quantitative measures or thresholds/limits for various types of soil disturbance are generally *not* provided in the Supplement, recognizing that one-size-fits-all 'standards' are often inappropriate for particular or differing soil types, and recognizing that disturbances need to be evaluated in a site and soil specific manner during assessments and analyses. The objective is to avoid or minimize disturbances that may impair key soil functions for the activity area, as that is defined. Areas rated in a poor condition should be considered for restoration activities.

Specific measures, indicators, and thresholds are established at the project scale in assessing soil condition, and for evaluating the effects of the proposed project on the soil resource: what gets looked at, why, and interpretation of what it means to soil quality and site productivity. This is described for this project in the methods and analysis sections below.

2.2 FOREST MANAGEMENT DIRECTION, STANDARDS AND GUIDELINES

The proposed project falls on lands of two National Forests, a lesser portion on the Six Rivers NF and the bulk of the acres on the Klamath NF. This portion of the Klamath on the Ukonom Ranger District is administered by the Six Rivers, although the Klamath LRMP provisions are still mandated for these Ukonom lands. Thus the whole of the project area is administered by Orleans Ranger District, but there are two sets of LRMP standards that apply. Provisions of each LRMP relating to soils are provided below for comparison here in one place.

2.2.1 Six Rivers National Forest Land and Resource Management Plan (1995)

The Six Rivers National Forest Land and Resource Management Plan (LRMP) establishes Forest-wide management direction, and Standards and Guidelines in carrying out project activities. Soil Quality Standards in this LRMP mirror almost verbatim the old (1991) R5 Supplement's Soil Quality Analysis Standards, so most of the arbitrary quantitative thresholds contained therein are still in place on this Forest until Plan revision.

The LRMP provides measures and threshold values that indicate when changes in soil properties and soil conditions *may* result in significant change or impairment of key soil functions – soil productivity and hydrologic function. Soil disturbance is considered "detrimental" if thresholds are exceeded *and* subsequent impairment of soil functions is judged likely after a soil & site specific assessment. Detrimental disturbance refers to the *severity* of impacts, which may be very small scale in occurrence.

The *extent* of detrimental soil disturbance shall not be of a size or pattern that would result in a significant change in productivity for the activity area. Fifteen percent of an area is conventionally used as a limit for detrimental disturbance. Note that the activity area is the scale at which impacts are ultimately assessed, defined as the area where soil disturbing activities take place, such as a timber harvest unit in a sale area or a burn area within a prescribed burn project. System roads, trails, and other areas not dedicated to growing vegetation (other dedicated uses) are not included as part of the activity area.

Thus both *severity* and *extent* of detrimental disturbance are important considerations that must be evaluated together to assess potential adverse impacts on soils of the activity area. As such, detrimental disturbance can be allowed on a small portion of a unit – this does not constitute adverse impacts; conversely, minor disturbance can be allowed in most of a unit, this likewise does not necessarily constitute adverse impacts. Detrimental disturbance in > 15% area is used to constitute adverse impacts.

2.2.1.1 Forestwide Standards and Guidelines (LRMP, pp. IV-65, IV-73 to IV-74)

Standards and guidelines [2 thru 6] relate to soil productivity in forest and range production areas. They do not apply to lands dedicated to other uses, such as administrative sites or transportation system roads.

1. Design management operations to maintain the existing productivity of the site.
2. Implement Forest soil quality standards as described in Appendix L.
3. For each harvest unit, soil porosity will be maintained to at least 90% of its natural condition over at least 85% of the project area. [compaction standard]
4. Where soils are susceptible to compaction [high compaction hazard rating], actions will be required to mitigate or avoid compaction [examples given].

5. Tractor skid trails should be limited to 15 percent of the harvest area. [logging systems]
6. Mechanical slash piling will be limited to the normal operating season, unless a special prescription is developed. [as in Wet Weather Operation Standards]
7. The potential for increased mass movement and soil erosion will be addressed for proposed timber harvest and road building. [project design and EHR system]
8. Roads, landings, and timber harvest units will be located and designed to avoid triggering or accelerating mass movements. [project design]
9. Tractors will be limited to slopes of 35% or less in order to minimize soil disturbance and subsequent erosion. [logging systems]
10. Best management practices (BMPs) will be implemented for land disturbing activities as a means to achieve state water quality objectives. [Appendix M, except as changed with new State Water Quality Control Board requirements as of December 2011]

2.2.1.2 Soil Quality Standards (LRMP, Appendix L)

Soil Quality Standards (SQS) provide threshold values to identify when changes in soil properties or conditions become detrimental. Areas of detrimental soil disturbance that affect productivity should not be of a size or extent that would result in a significant change in production potential for the activity area, generally assumed to be 15% area. Some standards are qualitative and some are quantitative. The Six Rivers SQS use the following soil properties, conditions, and threshold values to evaluate management effects on the key soil functions of soil productivity and hydrologic function.

1. Soil cover for erosion prevention is sufficient to prevent the rate of accelerated soil erosion from exceeding the rate of soil formation [which is unknown and unknowable; number 2 is assumed to meet this objective unless stated otherwise for particular sites].
2. The kind, amount and distribution of soil cover necessary to avoid detrimental accelerated soil erosion is guided by the Region 5 Erosion Hazard Rating system (R5 FSH 2509.22) and locally adapted standard erosion models and measurements.
3. Soil porosity is at least 90 percent of the total porosity found under undisturbed or natural conditions. Porosity is evaluated between 4 and 8 inches below the surface. [compaction standard, 10% reduction in total porosity is "detrimental"].
4. Organic matter is present in sufficient amounts to prevent significant short or long-term nutrient cycle deficits, and to help avoid adverse physical soil characteristics [kinds and amounts of organic matter follow].
5. Soil organic matter in the upper 12 inches of soil is at least 85 percent of the total soil organic matter found under undisturbed conditions for the same or similar soils. [displacement standard; notably this is highly uncertain in measuring or implementing].
6. Litter and duff occurs over at least 50 percent of the activity area. Use the presence of living vegetation that could contribute significant annual litterfall to compensate for conditions when post-disturbance litter and duff coverage is less than 50 percent.
7. Large woody material, when occurring in forested areas, is at least 5 logs per acre in contact with the soil surface. Desired logs are about 20 inches in diameter, about 10 feet long, and represent the range of decomposition classes [as defined]. Attempt to protect

logs in decomposition classes 3-5 from burning and mechanical disturbance. Large woody material requirements may be waived in strategic fuelbreak areas.

8. Infiltration and permeability are not reduced to ratings of 6 or 8 as defined in the R5 EHR system. [soil hydrologic function standard; “water movement” rating in EHR]
9. Soil reaction class, buffering or exchange capacities, or biological populations are not altered to the degree that significantly affects soil productivity, soil hydrologic function, or the health of humans and animals. [soil chemical and biological standard; this is another unknowable and non-implementable standard; notably the language this was taken from in the old R5 Supplement tied this to “materials added to the soil” will not have this effect, originally intended for fertilizer or herbicide applications].

2.2.2 Klamath National Forest Land and Resource Management Plan (1995)

Soil cover guidelines, BMPs, coarse woody debris requirements (5-20 logs per acre), [and] the requirement to minimize intensive burns during site treatment and the fuels management program are expected to maintain soil productivity. The aggressive fuels management program is expected to reduce the amount of high intensity fires, thus protecting soil productivity. [LRMP, p. 2-2].

The soils most susceptible to wind and water erosion are loose sandy and silty soils without ground cover. Vegetative removal has little direct effect on the erosion from these soils. Much more important is the ground cover and organic liner [*sic*, litter] from the vegetation. Soils bare of vegetation but with 50-80% ground cover are effectively protected from wind or water erosion. [LRMP, p. 3-2].

Tractor yarding is limited to slopes less than 35% [LRMP, p. 3-19, silvicultural systems].

Forestwide Goal: Carefully conserve resources that cannot be replaced. Cultural resources, soil, species and genetic diversity require special management due to their irreplaceable nature. [LRMP, p. 4-4].

Forest Program Emphasis, Soils: Maintain soil productivity. Reduce the level of management activity-related soil erosion where soil erosion has been identified as adversely affecting beneficial uses. [LRMP, p. 4-5].

2.2.2.1 Forestwide Standards and Guidelines (LRMP, pp. 4-18, 4-20 to 4-21)

The intent of standards and guidelines is to meet the stated goals and objectives. The standards and guidelines describe what will and will not occur in a particular area to achieve the desired goal. The following are Forestwide Standards and Guidelines (S&Gs) pertaining to soils:

Project planning and implementation:

1. Identify areas of unacceptable soil erosion during project planning or implementation so project plans for restoration and improvement can be developed (S&G 1-2).
2. Implement BMPs to meet geologic, water, soil, and air quality objectives (S&G 1-3).
3. Plan and implement land management activities to maintain or enhance soil productivity and stability (S&G 3-1)

Soil Erosion:

4. With the exception of roads, permanent facilities or other projects that will permanently occupy a site, the following levels of total soil cover should be maintained at the stand level to reduce the potential of soil erosion: [Table 4-2, Soil Cover Guidelines for Projects, LRMP, pg. 4-20] Maintain soil cover of 50% to 80% depending upon project type, soil texture and slope (S&G 3-2). [Note this is a guideline, not a standard]

Soil Productivity:

5. Maintain soil productivity by retaining organic material on the soil surface and by retaining organic material in the soil profile (S&G 3-3).
6. A minimum of 50% of the soil surface should be covered by fine organic matter following project implementation, if it is available on site (S&G 3-4).
7. Maintain a minimum of 85% of the existing soil organic matter in the top 12 inches of the soil profile to allow for nutrient cycling and maintain soil productivity (S&G 3-5).
8. Refer to the Coarse Woody Debris (CWD) section of the Biological Diversity under Biological Environment for coarse woody debris standards and guidelines designed to maintain soil fertility and provide for species needs (S&G 3-6).
9. Complete a Soils Resource Inventory Order 2 inventory when necessary, or field verify the Soils Resource Inventory Order 3 survey, during the planning and implementation phase of each site-disturbing or vegetative manipulation project. Develop soil conservation management practices for each project as needed (S&G 3-7).

Coarse Woody Debris (CWD) (LRMP, pp. 4-23 to 4-24):

10. The objective is to provide CWD well-distributed across the landscape in a manner which meets the needs of species and provides for ecological functions (S&G 6-16).
11. Maintain 5-20 pieces of CWD per acre in various states of decay. The specific amount of materials specified for retention on individual projects shall be determined by the project ID team (S&G 6-16b).
12. Leave large logs, conifer and hardwood (reflecting the species mix of the original stand), sound and cull of at least 20 inches in diameter and about 40 cubic feet in volume when they are available. [Decay Classes specified]. Do not count logs less than 12 inches diameter or stumps as CWD. This guideline may be waived in strategic fuelbreak areas (S&G 6-16b).
13. CWD already on the ground should be retained and protected to the greatest extent possible from disturbance during treatment (S&G 6-16c).
14. As with all standards and guidelines, these guidelines are meant to provide initial guidance, but further refinement will be required for specific geographic areas (S&G 6-16e).

Timber (LRMP, pp. 4-45 to 4-47):

15. Silvicultural systems shall meet the resource management objectives of the area, including long term site productivity (S&G 21-12) [abbreviated]
16. Modify harvest methods to minimize soil and litter disturbance…Minimize soil and litter disturbance that may occur as a result of yarding and operation of heavy

> equipment, and reduce the intensity and frequency of site treatments…Soil compaction, and removal or disturbance of humus layers and CWD, may impact populations of fungi and arthropods. (S&G 21-20) [abbreviated]

2.2.3 Comparison of LRMPs

Both Forest Plans were published in 1995 and selectively incorporated language from the old redacted 1991 R5 Supplement – the Six Rivers more, the Klamath less. The Klamath LRMP does not have Soil Quality Standards as an appendix or elsewhere in the Plan, only their S&Gs. However, essentially all of the Klamath S&Gs are in common with Six Rivers S&Gs and/or SQS provisions; the Six Rivers Plan has some additional detail that the Klamath Plan lacks. There is nothing that conflicts with regard to soil provisions between the two Plans. Within both plans, surface organic matter retention levels for purposes of a) erosion prevention and b) nutrient cycling may or may not be the same levels, which should be determined in the project specific analysis.

In practice, the only substantive difference with soil standards is that the Klamath Plan lacks a compaction metric and lacks a specific aerial extent of detrimental disturbance that should not be exceeded, i.e. 15% area. The Klamath Plan is more general, simply stating #16 above without quantifiable metrics. Notably, Klamath SOP for decades defaulted to the R5 SQS at the time (Laurent, retired Klamath soil scientist, personal communication), which is in effect the same standard that the Six Rivers incorporated verbatim into their Plan.

This project will aim to comply with both Forest Plans using common soil management objectives and PDFs for the whole of the project area to make implementation consistent and less confusing. This represents a conservative approach toward maintaining soil quality and productivity, and is intended to comply with both LRMPs and satisfy the intent of NFMA (1976).

3 METHODOLOGY

3.1 SOIL RESOURCE INFORMATION

Soils information for the project area was obtained from two sources. The Klamath and Six Rivers National Forest Soil Resource Inventories (SRI) were primarily used for soil mapping coverage and various soil interpretations (e.g. susceptibility to burning damage). The NRCS Web Soil Survey[1] has publicly available soil mapping, map unit descriptions, information on soil physical, chemical, and engineering properties, along with additional NRCS soil interpretations. This was used to obtain official series descriptions, updated taxonomy information, and lab information (such as clay and organic matter content), realizing that such properties likely differ from the site-specific soils being assessed, but useful to rate soils on a relative basis for general sensitivity to various kinds of disturbance. Ultimately, soil resource information was field-verified to assure accuracy of soil properties and interpretations at the site/project scale.

3.2 SOIL EROSION HAZARD RATING

The Region 5 Soil Erosion Hazard Rating (EHR) System (USDA Forest Service, 1990) was used to rate the risk of soil erosion for all soils in the project area. This system uses various physical soil properties along with climate and site-specific factors to rate soils for hazard of sheet and rill erosion. This system can also be used to determine the amount of surface cover necessary post-activity to avoid raising the erosion hazard rating to a higher risk level, and to determine the slope gradient at which EHR becomes higher with other site factors held constant. Hazards of gully erosion or mass wasting are not addressed with this procedure; these are evaluated on site during site visits.

3.3 FIELD OBSERVATIONS

Why: The purpose of the field investigations were to: 1) validate the soil mapping coverage; 2) gather information on site-specific soil properties; 3) assess current soil conditions as affected by past management activities; 4) develop predictions on soil response to the proposed treatments within the units.

Where: A unit selection strategy was used to determine which units should have field visits with site-specific data collected. Units proposed for ground-based harvest, mastication and other mechanical treatments were the priority for field reconnaissance, since these activities present the highest potential for lasting impacts to soil resources. All of these units were visited. A selection of other units, based upon soil type or topography, had at least a walk-through to verify soil mapping and make ocular estimates of past disturbance. Many of the remaining units were not visited by soil scientists where it was determined, considering proposed treatments in combination with project-wide soil PDFs applied, that there was a low potential for adverse soil effects to occur; these are the manual and hand-treated fuels units, where no heavy equipment or commercial removal of timber is to occur.

Who: Field surveys were conducted by journey level soil scientists Scott Hagerty and Dave Young on numerous dates from May 2015 to November 2016, with most of the field investigations occurring in the summer of 2016. Both soil scientists have decades of experience with implementing activities such as those proposed here, and assessing the range of soil impacts that may be expected to occur.

[1] See http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

What: Field surveys were largely ocular, meaning emphasis was given to traversing a large portion of unit areas and visually observing the range of conditions and kinds and amounts of disturbance from past activities, with soil pits along the way to document soil types and condition. Most soil pits were relatively shallow (1-3 ft deep) as physical soil impacts are largely confined to this surficial layer. Profile horizonation, texture, structure, rock content, and color were used to distinguish and identify different soils for mapping validation, as well as evaluating resistance and resilience of soils to physical impacts, for example susceptibility to compaction. Other site specific data was collected for the analysis portion below, mainly site and topography data such as slope gradient, soil cover amount and components including rock cover, and coarse woody material (CWM) concentrations.

Current soil conditions in undisturbed state were observed, as well as altered states resulting from past management effects. Most of the mechanical units have some level of past management history using ground-based equipment, as detailed below. Old features such as skid trails, landings, and former temporary roads were inspected for degree and extent of detrimental soil conditions, in particular erosion features, compaction, and soil displacement. Legacy problems and restoration opportunities were also identified for ID team discussion.

A LiDAR bare earth DEM was available for the project area. This was highly valuable for mapping old temporary roads, as well as creating high resolution slope gradient maps; these maps were prepared and carried in the field during site visits, which made field review much more efficient. Steep inclusions within mechanical ground based units could be easily identified spatially in GIS, and this was very accurate in the field. Ocular estimates, aided by LiDAR, were made for the overall detrimental soil conditions for each of the ground-based treatment units.

3.4 ANALYSIS METHODS AND ASSUMPTIONS

Analysis first requires an assessment of the existing or baseline condition and then a prediction of the effects from the proposed activities. Existing current conditions were determined in the field in 2015 and 2016 field seasons. Soil impacts from proposed activities consider the types of activities, types of equipment and manner of operations expected, potential for detrimental disturbances, including where and to what extent, and further how long impacts are expected to persist considering expected rates of natural recovery or revegetation.

Information sources include the proposed silvicultural prescriptions (including treatment methods), aerial photography, NRCS and USGS certified data, Forest GIS layers, Forest Soil Resource Inventories (USFS, 1995a and 1995b), custom GIS products generated for this project, field notes from site visits, and other interdisciplinary specialists' input (particularly geology, hydrology, silviculture, and fuels).

It is assumed that application of required Best Management Practices (BMPs) as well as Project Design Features (below) concurrent with the project will be effectively applied as intended, meaning they will be implemented and achieve desired objectives on the ground. Erosion prevention is an end-result objective; it is assumed that any necessary additional or corrective actions will be implemented by responsible parties to achieve this end-result. The author will likely be available to observe field operations during early implementation of the project to confirm assumptions and expectations.

Regarding silvicultural prescriptions and mechanical operations: Some unit prescriptions are general in describing removal components; retention components; fuels reduction through hand and/or mechanical means and/or fire; access via old and/or new temporary roads needed in certain units; old and/or new landings to be utilized, etc. Prescriptions when general are to confer flexibility for implementation as site specific conditions warrant at the time; however different activities carry different consequences for analysis purposes. It thus must be assumed for analysis that the more-disturbing of alternate practices will be used, i.e. "conservatively" estimating more rather than less soil-disturbing methods will take place. For example many of the units involve pile burning, with piling accomplished by hand and/or tractor piling; for analysis it is assumed to be mechanical as the more impactful option. Some of the Project Design Features are prescribed with this in mind, which risk being overly-restrictive where less-disturbing activities wind up being chosen. This is necessary to address the range of soil disturbing activities that may be expected to occur and ensure compliance with LRMP standards. Mechanical treatments are expected to be restricted to allowable slope gradients as specified in PDFs. Units are further assumed to be treated in designated portions over approximately 10-15 years, so impacts will be spread out over time, not all at once or in a couple years like the scope of a conventional commercial timber sale.

3.5 SPATIAL AND TEMPORAL BOUNDING OF THE EFFECTS ANALYSIS

For soil resource analysis, the analysis area for direct effects is bounded spatially by the entire "footprint" of the project activity units, as this is the full extent of direct soil disturbing activities. The R5 Supplement and the Forest Plans indicate that the activity area is an appropriate scale to analyze project effects on the soil resource. LRMP Soil Quality Standards and/or S&Gs are intended to be used at this scale to determine project effects on key soil functions, focusing here upon soil productivity, soil hydrologic function, and on-site erosion potential.

For indirect and cumulative effects, the analysis area is likewise the same as the proposed project area (unit areas only). Although surface runoff egressing the project units has a potential to indirectly affect adjacent downhill slopes, it is only relevant where 1) runoff may be expected to occur, and 2) site-specific topography indicates runoff could pose additional off-site scouring, erosion, or water quality concerns. It is an assumption that runoff and erosion concerns are expected to be controlled on-site through effective BMPs and drainage controls. Thus the analysis area for soils = the proposed project area.

The analysis is further bounded in time by the foreseeable future period during which effects of this project could persist as detectable, significant effects. Some soil impacts, such as cover reductions, can naturally recover quite quickly from needlecast and other organic debris deposited on the forest floor. Others, such as compaction and effects of displacement, can persist for decades. In general, expectation for temporal longevity of effects is discussed as short-term (< 5 years), mid-term (5-20 years), or long-term (> 20 years) effects. For cumulative effects, the analysis is bounded in time by past, present, and reasonably foreseeable future projects.

By adhering to SQS and/or S&Gs for erosion, compaction, displacement, and organic matter components, key soil functions described above are assumed to be maintained, in both space and time. A further level of analysis and discussion is warranted where SQS are expected to be exceeded in significant portions of the unit area. Greater than 15% area has conventionally been used for an extent threshold of concern for soils; this is not technically specified in soil standards at any level, but it is used repeatedly for several individual criteria.

3.6 ANALYSIS INDICATORS

The effects of individual management activities on the soil resource, pertaining to soil productivity and soil ecosystem function, is guided using the regulatory framework outlined above, with particular emphasis on the most specific guidance: the Six Rivers and Klamath National Forest(s) LRMP Standards and Guidelines, and the Soil Quality Standards in the Six Rivers LRMP (Appendix L).

Three indicators were chosen that best address relevant soil issues in the Project and measure compliance with Forest Plan Standards and Guidelines. The indicators include soil stability (soil cover for erosion prevention), soil organic matter (conservation of), and soil structure & porosity (limiting aerial extent of compaction and displacement). The unit measures for each indictor are percentage area (acres) not meeting desired conditions, as set forth from applicable Forest Plan SQS and/or Standards and Guidelines.

4 AFFECTED ENVIRONMENT

4.1 GEOLOGY AND GENERAL SOILS

The greater geologic setting spans a range of the Klamath Mountains geologic terranes, from Rattlesnake Creek Terrane and Galice Formation in the Western Klamath terrane, to Western Hayfork terrane in the Western Paleozoic and Triassic belt. Imbricate thrust sheets that constitute the various terranes generally are sequentially younger and structurally higher further west, but complex structural relationships confound this simple model. Lithologies include metavolcanics and metasediments with minor amounts of intrusive rocks (granitics and gabbro) and ultramafics. Numerous terrane-bounding thrust faults cross the area, in a general north-south orientation. Fault-shearing and associated rock incompetence and slope instability is common throughout the region. Areas of highly sheared rock generally correspond with zones of deep-seated instability and landsliding, including several large earthflows and prehistoric large landslides. The Klamath River canyon follows the north-south orientation of such terrane-bounding faults.

The project area itself is located in Klamath Ecological Subsections[2] M261Aa, Western Jurassic, and M261Ak, Lower Salmon Mountains. The Western Jurassic subsection is on the western portion of the Klamath Range. Lithology is the Western Klamath Belt, Galice Formation – slate, phyllite, and meta-graywacke with minor metavolcanic inclusions. These are Jurassic age clastic marine sedimentary rocks, slightly metamorphosed (meta-graywacke and slate). The Lower Scott Mountains subsection is the lower elevation portion of the central part of the Eastern Klamath Belt. Lithology is dominated by ultramafic rocks of the Trinity terrane, which is a complex assemblage of Cambrian to Devonian (Paleozoic) age oceanic crust materials, uplifted, metamorphosed, and further intruded by Mesozoic granitic rocks. Bedrock is thus a complex mixture of serpentinized peridotite, gabbro, diabase, and quartz diorite, with soils formed upon them differing accordingly.

Both ecological subsections are characterized by a Mediterranean climate – cold-wet winters and hot-dry summers. Geomorphology is characterized as rounded ridges with steep sides and narrow canyons and having developed a dendritic drainage network. Mass wasting and fluvial erosion are the main geomorphic processes. Both large and small landslides are common, particularly in the Western Jurassic. Main ridges are mostly northwest trending.

[2] Miles and Goudey, 1997.

Two dominant soil Orders are represented in the project area: Inceptisols and Ultisols. Inceptisols are “young” soils, exhibiting only moderate degrees of soil weathering and development. These soils have altered surface horizons that have lost base minerals or iron and aluminum, but have minimal subsoil development from eluvial/illuvial soil processes. Inceptisols often occupy steep upland slopes with high rates of geomorphic (natural) erosion, offsetting soil profile development. These soils are in equilibrium with their environment and will not “mature” until their environment changes. Parent materials are often coarse and resistant to weathering due to bedrock density and/or alteration from higher-grade metamorphism.

Inceptisols occupy approx. 63% of the project area, with highly variable soil depth. The natural vegetation is mixed conifer-hardwood forests of Douglas-fir, white fir, incense-cedar, ponderosa and sugar pines, tanoak, and black oak. On the very steep, stony, and rocky slopes where soils are the shallowest, canyon live oak is the dominant species.

Ultisols occupy approx. 31% of the project area. These are typically deep and well developed soils with a clay-enriched subsoil that is acid and low in base saturation from weathering processes (leaching). Most nutrients are concentrated in the topsoil, and the subsoil has a high water holding capacity, making these quite productive soils in this water-limited environment. These soils occupy stable landscape features where geomorphic rates of soil creep and natural erosion are low, such as ridges with low-gradient slope and stable midslope benches.

Two additional soil Orders (Alfisols and Entisols) occupy about 1.5% area, and two non-soil components (Riverwash and Rock Outcrop) occupy about 4% area. For management purposes, Alfisols are extremely similar to Ultisols, and Entisols are extremely similar to Inceptisols. Riverwash on dry stream terraces is highly resistant to mechanical management impacts.

Soil temperature regimes are mesic and moisture regimes are xeric. Soil rock fragment content (RFC) is primarily pebble size class with a minor component of cobble size class for all soils. The soil families are primarily derived by their taxonomic grouping at the family level, thus one soil family may be derived from differing parent materials (e.g. Clallam).

4.2 SOIL RESOURCE INVENTORY

The Order 3 soil mapping was judged based upon field review as having good accuracy and utility for project planning. No areas were found that had substantially different soil types which would change interpretations and conclusions regarding environmental effects of proposed activities.

In all there are 12 soil families within 15 soil map units in various combinations and component proportions (table 1). Riverwash bridges alluvial and dry-floodplain and stream terrace environs. Rock Outcrop is a non-soil component, but it is important because it generates immediate runoff that can erode slopes below (this is factored into project-specific EHR development below).

Soil distribution and slope gradient maps are in Appendix A, with table 1 serving as the soil map unit legend. Erosion hazard rating (EHR) calculations for all soils are in Appendix C. Select properties and risk ratings (including EHR) for the dominant soils are displayed in tables 2 and 3 below.

Table 1. Soil Map Units corresponding to Appendix A maps 1-4, extent (acres), and LiDAR-derived slope gradients (weighted average); *sr map unit suffix refers to Six Rivers map units.

Map Unit Symbol	Map Unit Name	Acres All Treatments (Alt. 2)	Acres Mechanical (Alt 2)	Slope (%) (all acres)	Slope (%) (mechanical)
109	Clallam deep, 15-70% slopes	143	0.1	42	69
110	Clallam very deep, 9-70% slopes	1,384	274	39	30
112	Clallam deep-Deadwood assoc., 50-90% slopes	801	48	52	27
114	Clallam deep-Goldridge gravelly assoc., 30-90% slopes	1,180	86	48	38
115	Clallam very deep-Riverwash assoc., 0-15% slopes	3.4	--	44	--
118	Deadwood-Clallam deep assoc., 50-90% slopes	140	7.1	51	38
119	Deadwood-Rock Outcrop assoc., 50-90% slopes	38	0.3	47	26
131	Goldridge gravelly, 15-50% slopes	1,209	528	33	25
132	Goldridge gravelly-Clallam deep-Prather assoc., 30-70%	240	58	42	31
133	Goldridge-Gilligan assoc., 15-90% slopes	1.4	--	64	--
174	Riverwash deposits	244	9.0	37	12
300sr	Rock Outcrop-Lithic Xerorthents complex, metaigneous, 60-90%	28	1.5	22	11
312sr	Holland deep, 30-50% slopes	17	2.2	36	32
316sr	Aiken-Holland complex, deep, 10-40% slopes	117	43	28	21
321sr	Hugo mod-deep-Maymen complex, 50-70% slope	21	--	58	--
Total:		5,570	1,058	42	28

Note: acres and slope% values for mechanical include units designated as “mechanical ground-based”; these units do include some steeper non-mechanical ground, skewing the average upward (e.g. soil 109)

Most of the soils within the project area are deep and very deep, well drained, with gravelly to very gravelly loam surface textures and finer-textured subsoils at depth; Clallam very deep is coarser-textured than the deep phase, and Deadwood is the only shallow soil with significant coverage.

Compaction risk rating (table 2) follows Roath (2006). Relatively high rock fragment content (RFC) and organic matter content are both beneficial in making topsoils moderately resistant and resilient to compaction from ground based machinery; only Aiken and Prather have a high compaction risk (no Prather soils were found during field review). Subsoils are gravelly clay loams or very gravelly sandy loams, with different manageability accordingly. Clay loam subsoils when shallow below-surface are more susceptible to compaction, and have a higher risk of exposing less-permeable subsoil from incidental displacement with mechanical ground-based yarding. This is the sort of risk identification that may drive development of unit-specific PDFs after field review.

Table 2. Dominant soil families and select properties and interpretations. Acreage is prorated from map unit components, less inclusions. Abbreviations are standard soil science conventions. EHR calculation uses LiDAR-derived slope gradients, being more accurate than map unit slope phases. All other soils have a map unit component extent <50 acres and <1% area.

soil family	**Clallam**	**Clallam**	**Goldridge**	**Deadwood**	**Aiken**	**Holland**
depth class	deep	very deep	deep	shallow	deep	deep
acres (mapped)	~1,360	~970	~1,200	~345	~65	~55
acres (approx. total %)	~32%	~23%	~28%	~8%	~1.5%	~1.3
A texture	vgL	gSL	vgL	egL	gL	vgL
RFC (top 12”, % vol.)	65-90	25-45	30-55	70	15-35	20-50
depth to texture Δ (in)	13	31	10	16	9	8
subsoil texture	vgCL	vgLS	gCL	R	gCL	gL
profile depth (in)	42	60+	60+	16	60+	60+
site class	3	4	1-2	4-5	3	3
soil hydrologic group	B	A	B	C	C	B
infiltration	mod. rapid	mod. rapid	moderate	moderate	mod. rapid	mod. rapid
permeability	mod. slow	mod. rapid	mod. slow	moderate	mod. slow	mod. slow
compaction risk	moderate	low	moderate	moderate	**high**	moderate
burn damage risk	moderate	low-mod	low-mod	moderate	low	moderate
EHR (current)	Low	Low	Low	Low	Low	Low
EHR (50-70% cover)	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
EHR (bare)	Moderate	**High**	Moderate	**High**	Moderate	Moderate
EHR (slope limit, %)*	80	65	80**	75	55**	55**
Taxonomy (Great Group)	Xerochrept	Xerochrept	Haploxerult	Xerochrept	Haplohumult	Haploxeralf
particle size class	loamy-skeletal	loamy-skeletal	fine-loamy	loamy-skeletal	**clayey**	fine-loamy

*Note: EHR slope limit (%) is the slope gradient at which EHR becomes High with expected levels of post-project soil cover (50-70%); this would indicate a need for soil cover additions above this limit to maintain a moderate or lower EHR; **denotes these soils do not occur on slopes this steep (e.g. Aiken).

Soil hydrologic groups (table 2) indicate the potential of a soil to produce runoff from long duration storms, when soils are already thoroughly wet and are not protected by vegetation. Groups range from A, indicating very low runoff potential, to D, indicating prone to flashy runoff with erosion consequences. Soils here are all rated A to C. Group C soils indicate moderate runoff potential due to their less permeable subsoil, shallower profile depth, or both.

Burn damage risk rating (table 2) indicates the susceptibility of heat to penetrate the soil during a fire, volatilize soil organic matter (SOM), and kill soil microorganisms. While this is primarily determined by fire intensity, soil properties such as texture, rock content, parent material, and organic matter content can influence heat penetration to some degree. Long term burn damage is mainly related to the loss of SOM, which requires long timeframes to accumulate within the soil. Soil moisture status at the time of burning also has a profound influence on heat penetration (Busse et al., 2010), but is not a factor in this rating system due to its transient nature. None of these soils have a high burn damage susceptibility rating, which is opportune for this project. That said, Rx burning activities still carry a risk of erosion if too much soil cover is removed, particularly on steeper slopes and soils with high EHR when bare.

Thus, from a manageability perspective, considering texture, depth, and interpretive ratings, these soils fall into two groups: 1) those with clay loam subsoils (Clallam deep, Goldridge gravelly, Aiken) which are more susceptible to compaction and displacement impacts, but less susceptible to erosion (because they generally occur on gentler slopes), and 2) those without CL subsoils (Clallam very deep, Holland, Deadwood) which are less susceptible to compaction and displacement impacts. Clallam very deep and Deadwood have higher erosion hazards, because of coarse textures for Clallam and a shallow soil profile for Deadwood, and then only when bare.

Table 3. Erosion Hazard Rating summary for all soils (calculations in Appendix C).

			(LiDAR)	Hydrologic	Erosion Hazard Rating		
Erosion Hazard Rating (EHR) summary table			(mean %)	Soil	Soil Cover		
Map Unit	Map Unit Name	Acres	GIS slope	Group	Current	Post-Treatment	Bare
109	Clallam deep, 15-70% slopes	143	42	B	L	M	M
110	Clallam very deep, 9-70% slopes	1,384	39	B	L	M	H
112	Clallam deep-Deadwood assoc, 50-90% slopes	801	52	B-C	L	M	H
114	Clallam deep-Goldridge gravelly assoc, 30-90% slopes	1,180	48	B	L	M	H
115	Clallam very deep-Riverwash assoc, 0-15% slopes	3.4	44	B-A	L	M	H
118	Deadwood-Clallam deep assoc, 50-90% slopes	140	50	C-B	L	M	H
119	Deadwood-Rock Outcrop assoc, 50-90% slopes	38	47	C	L	M	H
131	Goldridge gravelly, 15-50% slopes	1,209	34	B	L	M	M
132	Goldridge gravelly-Clallam deep-Prather assoc, 30-70% slopes	240	42	B	L	M	M
133	Goldridge-Gilligan assoc, 15-90% slopes	1.4	64	B	L	H	H
174	Riverwash deposits	244	37	A	L	M	M
300sr	Rock Outcrop-Lithic Xerorthents complex, metaigneous, 60-90% slopes	28	28	D-C	L	M	M
312sr	Holland deep, 30-50% slopes	17	36	B-C	L	M	M
316sr	Aiken-Holland complex, deep, 10-40% slopes	117	28	C-B	L	M	M
321sr	Hugo mod-deep-Maymen complex, 50-70% slope	21	58	B-C	L	H	H

Note: "current" condition assumes 95% ground cover, "post-project" assumes > 50% ground cover, "bare" includes only overstory canopy and rock cover.

Soil map unit 321sr has a High EHR with 50-70% soil cover, mainly because of a high average slope gradient. This area occupies a contiguous 21 acre area in Donahue, and is mostly within riparian reserve. All of the unit-area involved is proposed for manual/Rx burn treatment; this area will need to maintain >70% cover on slopes >55% to avoid an elevated erosion response (unit-specific PDF).

Soil map unit 133 also has a High EHR with 50-70% cover, also because of high average slope, but this soil was not found where it was mapped – 1.4 acres of unit 2107 in Ti Bar – rather it was the gravelly phase of Goldridge, map unit 131, so this soil unit will not be discussed further. Such minor mapping discrepancies for tiny areas are not uncommon, and are not significant to the analysis unless a drastically different soil type were to occur; here it was simply a different map-phase of the same soil. Map phases are usually based upon slope class and perhaps depth class; in this case Goldridge also has phases based upon rock fragment content (gravelly or not).

All of these management risk ratings collectively indicate the general sensitivity or resistance & resilience of different soil types to different kinds of disturbances or impacts. They are also used as a pre-field filter to help identify and prioritize emphasis areas for more detailed field review, to ensure that soils types which are generally more sensitive to management related impacts receive more attention and thorough review, given the management scenarios being proposed. Units are routinely dropped during the field review phase for various resource concerns, including soils and stability concerns when they pose higher risks. Again, these are the sort of risk factors that may drive development of unit-specific PDFs after field review.

4.3 CURRENT SOIL CONDITIONS

There have been past entries into the project area to harvest timber, implement prescribed burns, construct fire breaks, and respond to wildfire with suppression activities. Portions of the project area remain detrimentally disturbed, most commonly in plantations. Persistent disturbance is primarily compaction located in old landings, old temporary roads, and some primary skid trails near landings; some old temporary roads also have significant displacement. The assessment of current soil condition and past disturbance extent is based upon ocular estimates of disturbance collected when field reviewed. Severity of persistent past disturbance was assessed qualitatively, e.g. for compaction inspecting soil for platy structure and presence & distribution of fine to medium roots to estimate whether root growth pattern was affected (excluded or restricted).

4.3.1 Soil Cover (Soil Stability)

Bare soil was occasionally noted during field investigations, but was rarely observed in most units, and when noted was always small isolated patches (such as windthrow mounds) without significant sediment movement. The only exception were a few segments of old temporary roads, which were identified as legacy sites for repair actions. All mechanical and other units surveyed had ample ground cover (> 95% cover) to prevent soil loss from erosion. This is quite typical in a forested setting with decent site quality, both for units with no management history and those not entered for a decade or more. The average depth of fine organic matter, focused on duff, was 1-4 inches thick.

4.3.2 Soil Porosity (Compaction)

Detrimental compaction was visually assessed during unit field reviews, aided by LiDAR imagery, upon which many of the old temporary roads and landings could be seen and attention given to assessing the soil condition, particularly for proposed mechanical ground-based units. The majority of the plantations and some of the non-plantations on slopes generally less than 40 percent still exhibit signs of detrimental compaction. Most of the detrimental compaction appeared to occur on old roads and landings, and some (but not all) primary skid trails in proximity of landings. Secondary skid trails further out from landings were observed to have little to no compaction that would qualify as detrimental. It was also observed on fine-loamy soils, notably Goldridge, the well-used old skid trails, landings and temporary roads persist on the landscape, and naturally recover very slowly (as in several decades). Less-frequented old skids (with fewer passes) are assumed to be okay, since the more heavily trafficked ones are so very close to the threshold.

Field investigations conclude that historic temporary roads and landings may all be assumed to be over the detrimental threshold in terms of severity. Only a subset of old main skid trails have detrimental compaction. However old skid trails were universally assessed as occupying < 15% areal extent in proposed units, so all units currently meet applicable compaction standards.

4.3.3 Organic Matter

Organic matter currently exists in kinds and amounts sufficient to prevent significant nutrient cycle deficits, and to avoid detrimental physical and biological soil conditions, as described below. Kinds and amounts based on ocular surveys in units were universally consistent.

4.3.3.1 Soil Organic Matter (Displacement, Severe Burning)

Evidence of severe burning (from past pile burning or underburns) was not found in any of the proposed units. Old piles that had been burned were seen and inspected in a few units, which presumably burned hot, but sufficient time has passed such that effects of burning have apparently recovered, with no heavily oxidized or charred surface soils found. These piles were also acceptably "clean" or free of topsoil, so it was reckoned that brush rakes had been used in previous machine piling operations, with favorable results. Other soil displacement was only viewed as significant on a few segments of old temporary roads, the same segments having compaction and evidence of erosion, as discussed.

4.3.3.2 Fine Organic Matter (Nutrient Cycling)

Fine organic matter, including litter, duff, and woody material less than 3 inches diameter, currently occurs on about 95% of the area (visually estimated), and on average is 1-4 inches deep. This is considered quite sufficient for nutrient cycling purposes, and all proposed units currently meet applicable standards.

4.3.3.3 Large Woody Material (LWM) / Coarse Woody Debris (CWD)

LWM and CWD terms used in the two Forest Plans are interchangeable, and specifications for retention are virtually the same – 5 to 20 logs per acre, greater than 20 inches diameter and at least 10 feet long or 40 cubic feet in volume, and spanning a range of decomposition classes, as available on site. CWD levels were visually assessed during surveys by the soil scientists and/or wildlife biology crews. Non-plantation stands all currently meet or exceed this level of CWD. Plantations generally do not, and will not in the foreseeable future, lacking trees that large in the living stand for recruitment. In accordance with standards, where currently existing CWD is deficient, 5 logs per acre is not required post-activity, but existing logs > 12 inches diameter should be conserved to meet the intent of the standard.

4.3.4 Infiltration and Permeability (Soil Hydrologic Function)

Water infiltration is reduced in areas of units that were previously managed with mechanical ground-based entry, specifically on the old main skid trails, landings and temporary roads that are considered detrimentally compacted (section 4.3.2 above). This is generally estimated to be about 5-10% aerial extent of these units, and not exceeding 15% in any units. Soil water movement in other units without intensive management history is essentially unaffected.

Subsurface permeability is naturally slower in soils with clay loam subsoil (Clallam deep, Goldridge, Aiken), which is generally unaffected by surficial impacts unless exposed by displacement. Complete topsoil displacement was not observed in any substantial portions of any of the proposed units, except for some segments of a few of the old temporary roads. EHR infiltration-permeability ratings are currently 1-4, well below 6-8 as the Six Rivers Plan uses as a standard.

Besides the EHR water movement rating standard, impaired hydrologic function is conventionally indicated by signs of erosion. In ocular surveys, minor sheet erosion was only noted on a select few of the old temporary roads. Also noted was that re-deposition of fines generally occurred over short distances (< 10-20 feet), so the eroded soil materials and nutrient capital remains on site. There were no larger contiguous areas (> 100 sq. feet) with signs of erosion to be of concern. Current soil hydrologic function of soils is judged as acceptable and meeting applicable standards in > 95% of the project area, with the exception as noted on a select few of the old temporary roads.

5 ENVIRONMENTAL EFFECTS

The proposed project involves multiple purposes and needs, primarily alteration of fuels and forest structure as a prerequisite for reintroduction of fire as a more frequent and active element upon the landscape, in a more culturally traditional manner to restore cultural vegetation characteristics. Past management activities have occurred in a large portion of the project area, with some portion of a "footprint" persisting and observable today. The No-Action Alternative incorporates these past effects, and is analyzed as a baseline or yardstick to compare the end result of new and additive effects from the proposed action, if implemented.

5.1 EFFECT OF ALTERNATIVE 1 (NO ACTION ALTERNATIVE)

5.1.1 Direct Effects of No-Action

Direct effects of the No Action Alternative would be of no immediate effect at all on the soils, as soil disturbing project activities would not take place. Soil cover for erosion protection would not change. Present compaction levels would remain the same in the short-term, with very slow long-term natural recovery. Surface organic matter components would continue to accumulate faster than decomposition. Soil organic matter would be unaffected. Soil hydrologic function would be unaffected.

5.1.2 Indirect Effects of No-Action

Indirect effects of the No Action alternative would be the increased accumulation of organic matter in terms of surface and ladder fuels, with a corresponding continual increase in fire hazard. Fire hazard is not the probability of a fire ignition, but that a fire ignition (human or lightning caused) would result in a successful fire start and spread, and fire behavior would be more severe. Fire hazard already represents an unacceptable threat to specified values at risk within the project area due to present vegetation composition. The No Action Alternative would do nothing to alleviate the hazard, or manage risks associated with watershed values.

The threat of wildfire to the soil resource should not be underestimated. As fire intensity increases, the potential for soil organic matter destruction, nitrogen volatilization, microbial mortality, structure & porosity destruction, inducement of water-repellency, and erosion are greatly elevated. High soil burn severity can severely damage soils and cause long-term declines in soil productivity and hydrologic function. Post-fire erosion is probably the single greatest risk to long-term productivity of soils in this Region. In extreme cases, soils cannot be revegetated without management intervention, or type conversion of vegetation communities may occur. Low to moderate severity fire is not usually considered a serious threat to soil resources, so to the extent that management activities can reduce the occurrence of high severity fire, soil resources benefit in the long term. High severity fire may have other resource benefits, depending on scale, but not for soils as an essentially non-renewable and irreplaceable resource.

5.1.3 Cumulative Effects of No-Action

There would be no additional impacts to soils with No-Action, so there would be no additive effects of other past, present and reasonably foreseeable future actions, and therefore by definition no cumulative effects. Soils would continue to have natural ecological function and soil productivity would be unaffected relative to the current existing condition.

5.2 EFFECTS OF ALTERNATIVE 2 (PROPOSED ACTION)

5.2.1 Project Design Features (PDFs)

Environmental effects are analyzed with the intent and assumption that BMPs and the following Project Design Features (PDFs) are effectively applied to the proposed action, meaning they are implemented and achieve the intended results on the ground. BMPs are intended to manage water quality consistent with the Federal Water Quality Act (WCA) and State of California water quality programs. BMPs are not repeated here; see the project hydrologist's report for specifics. Notable here is that many of the BMPs concurrently address soils concerns to the extent they are intended to prevent or minimize surface erosion and sediment movement.

Project Design Features are additional prescriptive measures that aim to minimize and/or mitigate foreseeable adverse effects upon the soil resource. These measures are to be done in conjunction with operations for minimizing or treating unavoidable adverse effects.

Objectives of PDFs are to 1) minimize soil disturbance severity and spatial extent in the project units, and 2) mitigate adverse soil disturbance effects that cannot be avoided. Most PDFs are "end-result" provisions rather than numeric prescriptions; the latter are usually for compliance purposes when LRMP soil standards are numerically restrictive. Recommended PDFs specific to this project for soil management include the following:

1. Heavy equipment operations shall occur when soils are dry enough to avoid deep rutting or puddling; operate over a duff and slash "mattress" if possible.
2. Limit heavy equipment operations to 35% slopes and less; occasional short pitches < 100 ft and < 40% slope are allowable in strategic locations, straight up/down slope with no turning; this is meant to be situationally-specific and not as a general practice.
3. Limit temporary roads and landings and skid trails to less than 15% unit area, and pre-designate them; this is the 15% area with allowable detrimental soil disturbance.
4. Re-utilize old temporary roads and landings and equipment trails to the maximum extent possible, thus minimizing new ground disturbance and avoiding cumulative effects.
5. Single-pass feller-buncher and masticator routes are generally NOT restricted to 15% area, however these are limited to dry soil conditions as with skidding equipment, and effort should be made to minimize turning-related (skid-steer) soil displacement.
6. Avoid soil displacement: do not blade topsoil from skid trails and landings if possible; full bench skid trails shall not be constructed. Tractor piled burn piles shall utilize a brush rake and be free of topsoil, i.e. keep the brush rake above the surface duff layer, as duff does NOT need to be pushed into piles for fuel reduction objectives.
7. Maintain 50-70+% soil cover in units, as prescribed on unit-cards; duff and fine litter less than 3 inches diameter are the most desired soil cover components, but rock and larger wood also technically count as cover.
8. Broadcast burning operations: include in the burn plan specific means to achieve residual soil cover requirements (*generally* >50%), with preference for duff and fine litter cover; monitor fuel/duff moisture content prior to ignition so that duff will not be consumed over too much area. Protect existing CWD to the greatest extent feasible.

9. Pile burning operations: seek a balance between size, number, and distribution of piles to maintain overall soil cover requirements and keep bare areas separated by filter strip areas. Do not place burn piles adjacent to streams or wet areas to avoid sediment delivery. Place burn piles away from existing CWD.
10. Cable, yoder, and end-lining operations: maintain at least one-end suspension of the butt-end of the tree so the tree canopy end is dragged on the ground; linear gouging of the soil where it occurs shall require hand-waterbars and raking of duff and slash back onto the bare area in a timely manner with other erosion control measures.
11. Rehabilitate temporary roads and landings upon completion of a unit, to include decompaction by ripping (or preferably subsoiling if such equipment is available) followed by re-contouring if benched or constructed (created using cut and fill), and mulching with slash or seeding using FS approved seed mix. Exceptions may be applied on a site-specific basis as approved by the project soil scientist, intended for where rehabilitation will create more disturbance than it aims to resolve.
12. OHV barriers: the ends of temporary roads and skid trails where they intersect system roads should be blocked with available material (large wood or boulders) to discourage unauthorized motor vehicles and possible introduction or spread of noxious weeds.
13. Erosion control measures shall be kept concurrent with operations, and shall be in place: 1) prior to any shutdown for anticipated storm events, 2) prior to weekend shutdown if storm events are expected, or 3) prior to seasonal shutdown.
14. Sale administration staff should request a site visit by the project soil scientist for units where soil disturbance appears severe or excessive (> 15% area), for the soil scientist to assess possible rehabilitation needs for LRMP compliance.
15. Bare soil areas: areas rendered bare by mechanical operations or burning should be monitored for adequate and timely natural revegetation; areas that do not revegetate naturally within 2 years should be prescribed for mulching and/or seeding with FS approved seed mix to stabilize soils if signs of overland runoff and erosion are present.

Minor modifications of PDFs may be allowed with mutual concurrence of the project soil scientist, hydrologist, silviculturist, and sale administration staff. Substantial modification of PDFs at the contracting stage, or a line officer later deciding to not include certain PDFs without concurrence of the project soil scientist, may compromise the soil NEPA analysis herein and render findings of this report invalid.

5.2.2 Direct Effects of the Proposed Action

Direct effects are generally analyzed in the context of activity types and where they are expected to occur, i.e. what "footprint features" will be left behind and what are the soil impacts there. The direct effects of these activities are very largely predictable based upon expected methods of operations and location of activities in terms of topography and soils and vegetation composition, the latter indicating types and amounts of removals or general treatment intensity. The effects of these different activities on the soil resources are well understood from years of experience planning and monitoring the effects of such activities on a wide variety of soils.

Temporary roads and landings are the most impactful features associated with activities, in particular ground-based (tractor) operations. These will have severe compaction, and thus have reduced infiltration and be prone to producing runoff; drainage features are required to control runoff and avoid adverse impacts (BMPs). Being "temporary" means that they will need to be rehabilitated once their use is finished. PDFs herein stipulate that rehabilitation will include decompaction via ripping (furrowing using conventional rock-rippers common on logging equipment) or preferably subsoiling (using specialized winged-subsoiler, if available); this would be followed by re-contouring to the approximate original terrain if the feature was "constructed" by blading topsoil to create a favorable grade or bench (constructed using cut & fill). The proposed temp roads and landings are generally on gentle slopes and benches, so little blading should be necessary to make them usable, and thus little to no recontouring is expected to be necessary; however some form of decompaction equivalent to ripping or subsoiling will be necessary. These areas will also be rendered bare, so some form of soil cover may be required to prevent erosion, either organic mulch, slash, and/or seeding to establish vegetation. In most cases, old access roads and landings are in favorable locations to be re-utilized, which will minimize new disturbance and cumulative effects. Even with rehabilitation measures, temp roads and landings will still have long-term effects left to slowly recover naturally over time.

Table 4. Proposed activity types and acres by soil map unit (Alternative 2).

	Activity Type (Alternative 2)						
Soil MU	**Manual**	**Mastication**	**Mech-Cable**	**Mech-Road**	**Mech-Ground**	**Rx Burn**	**Total**
109	41	4.7			0.1	97	143
110	723	21	9.0	17	274	340	1,384
112	383	4.6	26	1.3	48	339	801
114	603	3.8	56	14	86	417	1,180
115	0.9					2.5	3.4
118	50			7.2	7.1	76	140
119	3.2				0.3	35	38
131	477	55	12	33	528	104	1,209
132	97	56			58	29	240
133	1.4						1.4
174	186				9	49	244
300sr	2.6	24			1.5		28
312sr	15				2.2		17
316sr	57	17			43		117
321sr	18					2.9	21
Total	2,658	187	103	73	1,058	1,492	5,570
Percent	48%	3.4%	1.8%	1.3%	19%	27%	100%

Skid trails will be created as necessary to operate the mechanical ground-based units. These will also have compaction, but not as severe as temporary roads and landings. These may or may not have "detrimental" levels of compaction, depending on traffic intensity. A few passes with a tracked grapple-skidder will generally not produce a detrimental degree of compaction if soils are dry. Most soils have a moderate compaction risk; Aiken is the only soil within tractor units that has a high compaction risk. It is conservatively assumed that skid trail compaction will be detrimental, and these equipment trails in combination with temporary roads and landings should not exceed 15% of the unit area; trails must be designated or trail pattern pre-planned to ensure this aerial extent is not exceeded (PDF). If equipment trails are deeply rutted, they should also be decompacted by ripping or subsoiling and allowed to naturally revegetate.

Mastication uses specialized equipment to "chew up" or create wood chips from standing surface and ladder fuels (shrubs and saplings) and redistribute them on the soil surface. This creates increased surface fuels for some period of time, while reducing potential for crown fire. Chips are more or less directionally propelled during operations, which leaves a somewhat clumpy distribution of chips. If chips build up around tree boles, there is the potential for tree mortality from cambial scorch during (broadcast) burns. On the positive side, chips decompose over the course of 5-10 years, benefitting buildup of soil organic matter (SOM). Burns can be safely accomplished after a lag time for chips to decompose. Thick chip layers can also inhibit germination of some understory species for some time period, which there is little scientific information about (i.e. what species are more sensitive, in what settings, can it also inhibit invasive species?). Finally, large additions of carbon (C) to the soil can potentially immobilize nitrogen (N) through microbial metabolism for some period of time, and affect C:N ratios for plants. This effect was not seen on two intensively studied multi-site research experiments by PSW Research Station, despite great effort to document it (Zhang et al., 2016; Powers and Young, unpublished). All that said, mastication effects on fire hazard and understory development are temporary, which may or may not fit with other short-term management objectives.

There is a great variety of equipment used to accomplish mastication, which is *usually* smaller and lighter ground pressure than conventional harvest equipment, but not necessarily depending on specific equipment used, which is not necessarily known beforehand to estimate soil impacts. It is conventionally thought that operating upon a fresh masticated chip layer helps to protect soils from compaction effects, but to what degree likely depends on several factors.

Tractor piling of fuels for later burning is one the more controversial practices regarding soil impacts. In the past this was usually conducted with fixed-blade D-6 type tractors, resulting in much topsoil displacement into piles, and many passes with compaction effects, especially if soils were moist. Today this practice utilizes smaller tractors with 6-way blades and a brush rake attachment, which is nimble in piling fuels without the associated historic impacts. This project proposes using "low-impact machine piling" which refers to use of a smaller excavator to pile fuels, which is lower ground-pressure on the soils, and can reach out to operate a larger swath in fewer passes, usually single-pass. This kind of operation rarely produces detrimental levels of soil compaction (or displacement) unless operating in truly adverse weather (saturated soils).

Most units are proposed to have some extent of manual treatment, hand pile burn, or prescribed burn activities, discussed collectively as "hand-treated fuels" activities. Hand treatments are generally low impact, rarely creating impacts of a degree or extent that would be considered detrimental for soils, only foot traffic and potential burning effects for possible soil impacts. In some units this is the only treatment, with no mechanical equipment entry or commercial timber removals; in others it is a follow-up treatment after other intermediate fuels treatments.

Pile burning creates severe heating of soils under the piles, but these occupy a relatively small portion of unit area, and are surrounded by duff-covered soils to provide a filter strip to prevent sediment movement. Prescribed (broadcast) burning, conducted as desired, usually should not burn all of the duff to bare mineral soil, or only in patches; however this practice does have more potential to remove more duff from more of the area than may be desirable for soil cover and erosion prevention. Burn plans will need to be conservative, and explicitly take measures to retain required levels of soil cover – 50-70+% at unit-scale as stipulated by the Klamath Plan.

There are steep areas not suitable for mechanical operations (>35%) in nearly all of the ground-based units that will need to be avoided or only treated by hand. Steep areas should not be traversed with equipment unless just a short pitch < 100 feet, in which case equipment should go straight up-down slope, no turning, followed by installation of waterbars at close spacing, followed by some form of cover addition (e.g. slash). Slope maps are provided in Appendix A (though not useful scale here). The LiDAR imagery produces maps that are quite precise in location of steep areas. Thus some flexibility is allowed, but it carries additional mitigations.

It is expected there will be areas of bare soils after ground-based operations are complete, typically < 10% of unit area. These areas will be monitored for vegetation recovery, and will be actively mulched and/or seeded if any evidence of significant erosion is discovered, and/or if natural revegetation is not timely.

Cable and road-based mechanical treatments are generally lower impact on soils, especially with full suspension cable. Road-based cable generally only achieves single-end suspension, with some resulting soil gouging. With either system, a PDF specifies at least one-end suspension of the butt-end of the tree will be SOP, which will greatly help reduce gouging. Where gouging does occur, exposing bare soils, hand waterbars and raking cover back onto the corridor shall be done to mitigate water routing and potential for gullying since these activities are on steep to very steep slopes.

All of these direct impacts would not occur all at once; rather they would be spread out over the next approx. 15 years. BMPs and PDFs would be kept concurrent with operations. Thus the acreage extent of impacts at any one time would be annually variable over the life of the project.

Given the activity-centric context described above, effects below will now be discussed relative to the analysis indicators used to address (both) Forest Plan requirements, and where appropriate relative to specific activity type or specific units.

5.2.2.1 Soil cover for erosion prevention

Reduction of soil cover to varying degrees is a given by-product of proposed activities. This is acceptable given that residual soil cover still meets requirements for erosion prevention, generally 50-80% cover depending on activity type (tractor or burning) and soil surface texture (loam or sandy loam) per the Klamath LRMP, p. 4-20, table 4-2, copied below.

The only sandy loams where the higher cover levels are specified are Clallam very deep (Map Unit 110) and Lithic Xerorthents (MU 300sr). Note however these are guidelines, not standards. Site-specific EHR development (Appendix C) indicates that >50% cover is adequate to avoid a high erosion hazard, except only for Hugo soil which occupies about 21 acres in the Donahue focal area, most of which is riparian reserve and all of which is proposed for manual/Rx burn only; this area will require >70% cover (see "unit-specific mitigations" below).

All other areas have loam surface textures, and >50% soil cover in the form of duff and litter is estimated as sufficient to avoid a high erosion hazard. Only prescribed (broadcast) burning activities have potential to exceed 50% cover losses, and then only if the burns are much hotter than planned. It is expected that burns will be conducted with target residual cover levels in the prescription, and all units should accordingly meet this requirement at unit-scale post-activity.

Table 4-2. Soil Cover Guidelines for Projects		
Soil Texture Class	**Slope (%)**	**Minimum Total Soil Cover* (%)**
Guidelines for Projects Using Tractors:		
Sandy loam or coarser	0-25 26-35	70 80
Loam or Finer	0-35	70
Guidelines for Prescribed Burning Projects:		
Sandy loam or coarser	0-25 26-45 46	60 70 80
Loam or Finer	0-35 36-60 61	50 60 70
*Soil cover consists of low growing live vegetation (12 inches high), rock fragments (greater than 1/2 inch in diameter), slash (any size) and fine organic matter (charred or not) that is in contact with the soil surface. Fine organic matter refers to the duff, litter, and twigs less than 3 inches in diameter.		

5.2.2.2 Soil porosity (compaction)

The Klamath has no compaction standard in its Plan, but that Forest has historically used the same standard as in the Six Rivers Plan: detrimental compaction is a 10% reduction in total soil porosity, and this condition cannot occupy >15% area of an activity unit. All units surveyed currently meet this standard. For proposed activities, this would practically apply only to units with mechanical ground-based activities. One PDF specifies limiting temporary roads and landings and skid trails to less than 15% unit area, and this is a conventional standard that the Six Rivers sale administration staff is accustomed to implementing and achieving.

A handful of units are close to exceeding this standard currently with legacy tractor impacts, and these will require unit-specific measures to ensure compliance with the 15% area and avoidance of cumulative impacts (see "unit-specific mitigations" below). It is thus expected that all units will meet this standard post-activity.

5.2.2.3 Soil Organic Matter (SOM)

Soil organic matter (SOM) is organic matter and humus within the topsoil, which is crucial for nutrient and water holding capacity and long-term soil productivity. In Mediterranean climates, it is produced mainly from annual fine-root turnover, and to a lesser extent from fine surface organic matter additions; these are long-term processes, and long timeframes are necessary to accumulate SOM. The SOM is then vulnerable to loss from erosion (export), severe burning effects (volatilization), and displacement (redistribution, but still generally on-site). Erosion is explicitly part of the project design to prevent and avoid. Therefore, severe burning has the greatest potential to cause some loss of SOM and nutrients in the top several inches of soil, precisely where they are most concentrated (Wells et al. 1979; McNabb and Cromack Jr., 1990). This is a concern with the extent and frequency of burning being proposed with this project.

That said, burns that aim to preserve >50% duff cover for erosion prevention should likewise not be hot enough to significantly degrade SOM in the surface soil, except perhaps in small patches, as with pile burning. Broadcast burning prescriptions as practiced usually produce low to moderate <u>soil</u> burn severity (SBS), as opposed to 5-15% high SBS + 30-40% moderate SBS typical for wildfires in this vicinity (BAER records, on file with author).

Both Forest Plans have a SOM standard of retaining 85% of total SOM in the top 12 inches of soil. Though not stated, this standard is aimed at avoiding excessive soil displacement; notably it is non-implementable because even an experienced soil scientist cannot objectively determine compliance, or lack of. That said, soil displacement effects are a lesser concern for SOM loss, because the displaced soil is still on-site unless eroded, so the nutrient capital is still accessible by plant roots. This was a much greater concern historically when large brushfields were "reclaimed" for conifer plantations by "topsoil windrowing" to remove root-crowns of sprouting species that would be aggressive competition for resources, along with removing nutrient and SOM rich topsoil. It came to light that this practice was degrading to long-term soil productivity, particularly when windrows were spaced far apart and then many tree roots could not reach the enriched soil; such practices have not been conducted for several decades now.

Proposed activities, including burning activities, are expected to result in all units meeting applicable standards for SOM post-activity.

5.2.2.4 Surface organic matter (duff and fine litter)

Surface organic matter here is for the purpose of nutrient cycling, as opposed to erosion prevention above (5.2.2.1), which may or may not coincide as the same cover levels. Both Forest Plans specify at least 50% cover of duff and fine litter for soil productivity (with perhaps *more* needed for erosion prevention, as determined for the project). As already stated, it is expected that this level of soil cover will be met for all project units post-activity.

Furthermore, these are not clearcuts. A living forest canopy that continually adds litterfall to the forest floor will compensate in the short-term to cover small areas that may have burned hot or otherwise inadvertently removed more cover than desired. A healthy productive forest is the best case for self-maintaining favorable nutrient cycling, particularly on the more developed soils (Ultisols and Alfisols).

5.2.2.5 Coarse Woody Debris (CWD or LWM)

As stated above, CWD is generally sufficient in non-plantations and deficient in plantations currently. CWD contributes to SOM and habitat for arthropods that masticate fine organic matter into smaller particles that soil microbes can then utilize as food. CWD becoming SOM is an even longer-term process than for duff and litter, and in a fire prone setting most CWD probably never makes it to this state, but is consumed by fire sometime at higher levels of decomposition class. That said, the habitat value of CWD for arthropods, bacteria, and fungi is ecologically important. Field reviews were generally not quantitative in estimating CWD levels, so it is unknown whether non-plantations have enough "extra" CWD to compensate for plantations on a project-wide basis. Furthermore, CWD requirements are explicitly waived in strategic fuelbreak areas.

As with duff and fine litter, the extent and frequency of burning activities, specifically broadcast burns, have a real potential of consuming existing CWD and reducing overall levels of this resource. Since plantations do not have adequate size class of trees for CWD recruitment, the only practical management option is to protect existing CWD in non-plantations from mechanical disturbance and more importantly burning. Burn plans will need specific provisions to protect this resource (PDF). It is thus estimated in good faith that CWD will be protected to the extent practical, and CWD levels will increase over time, on average project-wide and eventually within plantations in the long-term.

5.2.2.6 Infiltration and permeability (soil hydrologic function)

The Klamath has no soil hydrologic function standard in its Plan; the Six Rivers Plan specifies that infiltration and permeability will not be reduced to a rating of 6 or 8 under the EHR system. The primary impact to soil hydrologic function is compaction by ground-based equipment, which usually only affects surface infiltration, not permeability as this is based upon subsurface water movement that is typically below compaction depth. The water movement rating becomes a 6 if infiltration is reduced from rapid to moderate on a shallow soil (e.g. Deadwood), or an 8 if infiltration is reduced to slow (< 0.6 in/hr) on any soil. Of note, the EHR system was developed primarily for agricultural soils; forest soils nearly always have rapid to moderate infiltration rates, being naturally more porous than equivalent Ag soils. Reduction of infiltration to 0.6 in/hr would be unusually severe levels of compaction, such as with a temporary road or winter-utilized landing (not frozen).

Soil hydrologic function is in good condition except in limited areas noted above (section 4.3.4), namely segments of old temporary roads comprising less than 5% area in previous ground-based units. This function is potentially compromised where severe compaction from ground-based equipment is expected, specifically temp roads and some landings if not rehabilitated. PDFs will limit heavy equipment traffic (including temp roads and landings and skid trails) to <15% area, which will satisfy the standard in all units, not just the Six Rivers where the standard applies. PDFs also specify rehabilitation of temporary roads and landings, including some legacy temp roads, so this condition is expected to be similar or improved on net-balance post-activity.

5.2.2.7 Unit-specific Mitigations (PDFs)

Because of differing soils types or differing levels of current legacy soil impacts, the following are units with additional requirements above and beyond PDFs, necessary to ensure compliance with LRMP standards.

Units with high EHR with 50-70% soil cover: The Hugo gravelly loam soils have a High EHR with 50-70% soil cover, mainly because they have high average slope gradients, on average above their EHR slope limit of 57%. Hugo occupies a contiguous 21 acre area in Donahue. These units require 70-80% cover maintained post-activity to avoid a High EHR, specifically in portions of the units mapped with these soils, and there upon slopes steeper than 55%.

Donahue: Units 2449, 2498, 2503, 2506, 2509 (portions of units, Appendix A, map A5).

Units with high levels of legacy (existing) ground-disturbance: A handful of units were observed during field review which have high levels of existing disturbance, primarily compaction from past ground-based management entry, approaching 15% area detrimental disturbance. These units require particular attention to reutilizing existing skid trails and landings (PDF) followed by subsoiling or at a minimum rock-ripping of main skid trails and landings when mechanical operations are complete; this is needed to ensure compliance with LRMPs.

Donahue: Units 2409, 2467, 2493, 2500.

Patterson: Unit 2242.

Ti Bar: Units 2117, 2119, 2127.

With these specific additional mitigations in these particular units, it is expected that they will comply with applicable LRMP standards post-activity.

5.2.3 Indirect Effects of the Proposed Action

Indirect effects relative to soils within the bounding area (section 3.5) include changes to the soil environment, reallocation of soil resources (water and nutrients) to fewer plants, changes in the distribution of organic matter upon and within the soil, and changes in potential soil damage from future wildfires.

The proposed action would create a short- to mid-term change in soil environment. Soil temperatures would be elevated due to opening the canopy and increased solar exposure of the soils. This would stimulate soil microbial and fungal activity and increase decomposition of soil organic matter and CO2 efflux from the soils. This would also synergistically stimulate root activity of vegetation, also increasing CO2 efflux but as importantly, increasing annual fine-root turnover which is a primary input to soil C and organic matter. On balance, soil C attrition in CO2 efflux would probably exceed accrual in root turnover for the first several years, then stabilize once revegetation and canopy expansion proceeds to shade the soil, then perhaps becoming a C sink from increased tree growth and vigor. This is all largely speculative, as current science has not yet formed reliable principles on effects of such practices, particularly belowground. Regardless, these effects would be temporary as the overstory canopy closes, understory fills in, and forest floor layers increase in depth over several years. Thus such effects are expected to be short- to mid-term, minor, and not relevant to long-term soil productivity. The scale of the proposed activities is not large enough to make net carbon sink or source estimates relevant to local or larger scale climate effects.

With thinning as a silvicultural practice, residual stocking of trees is supposed to be high enough to fully occupy the site, so finite soil moisture and nutrient resources are still fully utilized, just reallocated to fewer individual trees. Therefore thinning should have little effect on soil moisture or nutrient status. Trees will increase growth rates, expand crown and root systems, and would generally be healthier and more resistant to drought and insect attack with more available water and xylem flow.

Increased organic matter mineralization rates, as mentioned above, can provide short term benefits to microbial activity and soil nutrient status, but as that nutrient capital is ‘used up’ more rapidly, it can also possibly lead to nutrient deficits later. Conservation of surface organic matter as proposed with these activities is intended to maintain adequate nutrient cycling and prevent nutrient deficits. Often overlooked, the root systems of trees and vegetation that are removed remain in the soil, and slowly decompose to provide organic matter inputs directly within the soil, as well as provide readily available growth pathways for new roots through compacted soil. This is currently thought by investigators to be the probable explanation for a general lack of negative effects on tree growth with extremely-severe experimental compaction in the Long Term Soil Productivity study (Powers et al., 2005, Ponder, Jr. et al., 2012, Zhang et al., 2017, Busse et al., 2017). This experiment also tested effects of complete organic matter removals on soil nutrient status and tree growth, with no negative effects overall in the first 20 years to date. Thus, short-term pulse changes in organic matter presence and distribution upon the soil are not expected to significantly affect soil productivity.

Given direct localized impacts described above, mainly associated with ground-based operations, this should be balanced against a reduced potential for future wildfires to damage the soil in a more harmful fashion. On a Regional basis, fire is considered a much larger threat to soil productivity than active management activities, because the cumulative annual ‘footprint’ of fire is dramatically larger, and it causes much more erosion, which represents the most irreversible & irretrievable kind of soil damage. However, it is also unknown with what severity a future wildfire would burn on these particular areas, depending not just on fuels, but topography and weather conditions at the time as they influence fire behavior. It is reasonable to assume that fuel reduction activities *should* help moderate future fire behavior, and therefore benefit soil resources, at a cost of management impacts today. This is considered acceptable, as long as management related impacts are minor in scale. Soil impacts associated with proposed activities are expected to be mostly minor in severity, and ultimately minor in scale.

Other effects caused indirectly by direct soil effects (if *significant* as defined), could then include impaired watershed hydrology and water quality for fisheries; these are notably outside the analysis bounding area for soils. These concerns were however identified and discussed in the interdisciplinary-resource team setting, and are more appropriately addressed in others' specialist reports (hydrology and fisheries). Suffice to say here, direct soil effects of this nature (erosion and impaired soil hydrologic function) are not expected to be significant as a result of proposed activities, so these indirect effects do not warrant further discussion here.

In summary, indirect effects of proposed activities upon the soil resource are generally neutral or beneficial, are short-term in nature, and no adverse indirect effects are foreseen.

5.2.4 Past and Reasonably Foreseeable Future Actions

Past timber harvest activities have occurred in a large portion (55%) of the project area. Several past projects are listed in the Draft EA and are not repeated here. Past actions were for various silvicultural objectives (table 5), with different original soil impacts accordingly. Regeneration harvests occurred in 1957 to1988, followed by broadcast burning for site prep, replanting, and subsequent thinning about 20 years later. These old clearcuts are today's plantations. Soil impacts at the time for ground-based clearcuts (unknown how many are this) were no doubt significant, considering size and volume of materials skidded and removed, and larger, heavier equipment conventionally used for skidding at the time.

Table 5. Management History within Proposed Action Focal Areas (source: FACTS database)

	Focal Area					
Silvicultural Activity	**Ti Bar**	**Patterson**	**Rogers**	**Donahue**	**Acres**	**Years**
Thinning for Hazardous Fuels Reduction	424	292	80		796	2003-2006
Commercial Thin		78		155	233	1975-2009
Improvement Cut			19	14	33	1979-1981
Sanitation Cut		35		185	220	1983
Salvage Cut (intermediate treatment, not regeneration)		3.0			3.0	1968
Overstory Removal Cut (from advanced regeneration) (EA/RH/FH)		125			125	1973-1985
Patch Clearcut (EA/RH/FH)	126	101	38	273	538	1957-1988
Stand Clearcut (EA/RH/FH)	88	362	195	486	1,131	1957-1988
Total	638	996	332	1,113	3,079	1957-2009

Some thinning units are older but many are the most recent past activities, reflecting a change in management emphasis over time. Older commercial thinning units had significant aerial extent in skid trails, as there was no sensed need or direction to limit skidding before the early 1990s. Fuels reduction thinnings are the most recent past activities, in the last decade. If ground-based, these would have had a more limited footprint and would have used modern harvest equipment; an unknown number of these would have used manual methods as well, either exclusively or in combination with mechanical methods.

Most relevant for soils, regardless of past methods the remaining footprint of past activities can be observed in the field, and current condition assessed accordingly. Where past impacts cannot be observed today, they were likely minor impacts that have naturally recovered and are not significant today, or else they *would* still be apparent. This is bolstered by the finding that almost all of the lasting past impacts that *were* observed are not judged to be detrimental severity or significant in aerial extent today (see Existing Soil Condition and No-Action sections).

The only foreseen future project is the Six Rivers Aquatic Restoration Project. This project involves various activities aimed at instream habitat improvements and reconnection of side channels. Work would involve heavy equipment, but access to instream work sites would utilize only existing roads and trails and no new or temporary access routes (within these focal areas). Considering use of existing access and work focused on instream, this project is viewed as having negligible effects on terrestrial areas where this current project is to occur.

There are no additional foreseen future projects within the bounded analysis area. Presumably there will be future management actions in the vicinity at some point, but it is unknowable at this time as to what those actions may consist of, where they would be located, or the management setting and operational environment (e.g. biomass harvest, restoration, post-wildfire, revised LRMP standards, etc.).

5.2.5 Cumulative Effects of the Proposed Action

The proposed action and connected activities are to take place over the next approximately 15 years; for analysis purposes these are collectively considered the "present" action regardless of implementation timing. To reiterate, the cumulative effects assessment area for the soils resource is bounded in space within the proposed activity units, including any new road construction or reconstruction as connected actions, because this is the full extent of where soil disturbing activities are to take place. Effects analysis is bounded in time by Past, Present, and Reasonably Foreseeable Future Actions within this area. Effects from past management actions were discussed in the current conditions section 4.3, and expected direct and indirect effects of the proposed actions were discussed in sections 5.2.2 and 5.2.3 above respectively. A summary recap is provided again here.

Past: Effects of past management have almost entirely naturally recovered, with only a small portion of the old harvest footprint having soil disturbance that qualifies as detrimental under current soil management standards. Field review indicated that almost all of the previously managed stands have < 5% area with detrimental disturbance, with just a few (8 units) having existing disturbance that approaches 15% detrimental; these latter will require special mitigations to avoid adding to that (unit-specific PDFs).

Present: Impacts of the proposed action will by design occupy < 15% area of any individual unit, and will re-utilize old access roads, skid trails, and landings where possible, again to limit cumulative effects for individual units as a whole. "Where possible" is indefinite – sometimes reutilization of prior access routes and landings is not operationally pragmatic; it is expected with this project from field review that reutilization is entirely feasible. The direct and indirect effects of the proposed action are minimized to the degree possible, in severity and extent (considered in tandem), partly due to integrated Project Design Features.

Future: Known future planned activities will have negligible effects intersecting with the current project, as described above; equipment impacts would be limited to existing access routes, where soil management standards do not apply.

Current existing detrimental effects of past actions are minimal in extent area. The proposed action alternative by itself will not produce significant amounts of adverse direct or indirect soil impacts, using 15% area in detrimental soil conditions collectively as the threshold used to determine if soil impacts are significant, as per current management direction. Effects of reasonably foreseeable future actions are not expected to produce significant impairment of soil quality or productivity, because soil impacts are very limited to where soil standards do not apply. Thus there are no additive significant effects of past, present, and foreseeable future actions expected, and therefore by definition no significant cumulative effects for soil resources.

5.3 STATUTORY AND REGULATORY CONSISTENCY

All Alternatives are consistent with the regulatory framework outlined above. Forest Plan Standards and Guidelines (S&Gs) and/or Soil Quality Standards (SQS) are intended to comply with NFMA toward the end result of protecting soil productivity. S&Gs and SQS indicators were used as the context to describe and analyze the extent and magnitude of expected soil impacts, spatially and temporally. In complying with these Plan provisions, it is assumed that long-term soil productivity is maintained.

5.3.1 Forest Plan Compliance (LRMPs)

Both Alternatives are in compliance with Six Rivers and Klamath LRMPs relative to soil management direction. BMPs and PDFs will be implemented for the Action Alternative. Soil impacts are expected to be within allowable limits set forth by the Forest Plans.

5.3.2 Finding of No Significant Impact (FONSI)

The purpose of this report is not only to disclose impacts, but to evaluate those impacts in the context of NEPA significance (40 CFR 1508.27) to determine whether to prepare an EIS or a finding of no significant impact (FONSI). This report summarizes the potential impacts of the Alternatives in the context of analysis indicators used to assess soil resources. This report should provide sufficient evidence and analysis to substantiate a FONSI in connection with soil resources for this project EA.

5.3.3 Mandatory Disclosures (NEPA)

The Action Alternative involves adverse environmental effects to soil resources that cannot be wholly avoided or mitigated. There will be measurable negative effects in specific areas (temp roads, landings, some skid trails); however these are not expected to be long term or extensive enough to be significant at unit-scale. The aerial extent of these impacts is expected to comply with applicable standards (less than 15% area), and thus impacts are not considered to constitute a “substantial and permanent impairment” of soil productivity with respect to NFMA and R5 SQS. Project Design Features are developed in site-specific fashion and are intended to ensure compliance with the various elements of soil management direction. Physical soil impacts will be limited in aerial extent, and thus are considered acceptable for this project, in accordance with soil management direction.

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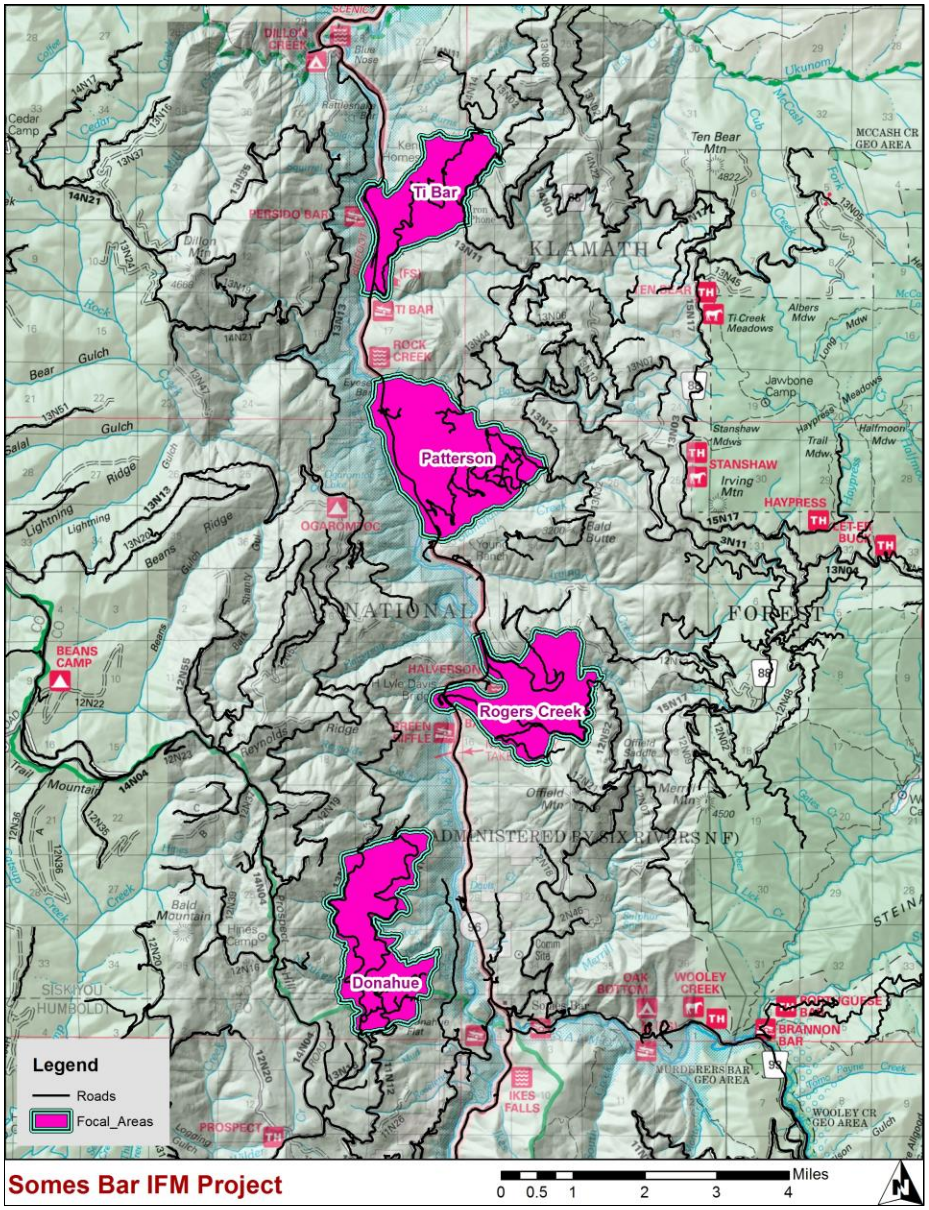
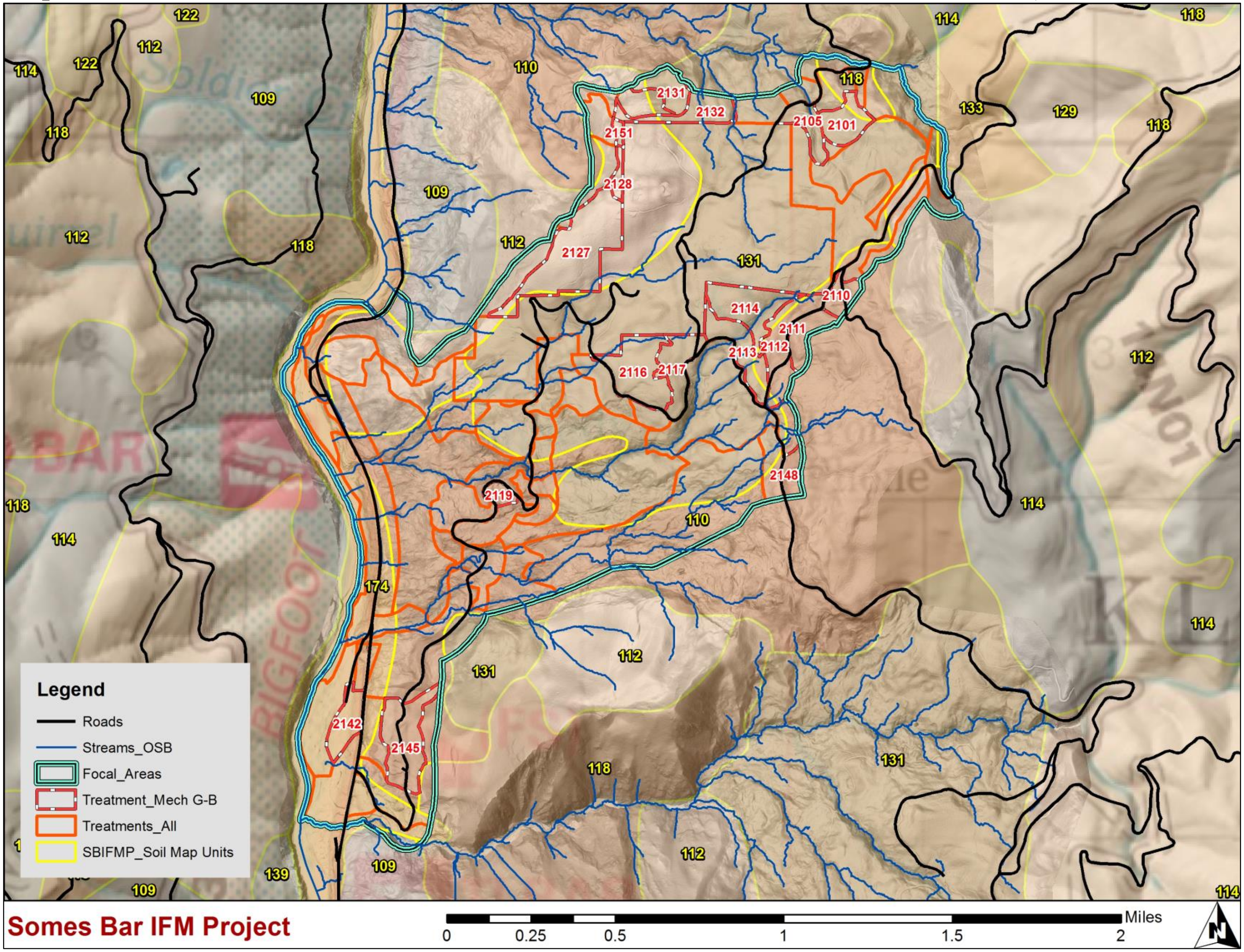
APPENDIX A – SOIL AND SLOPE GRADIENT MAPS



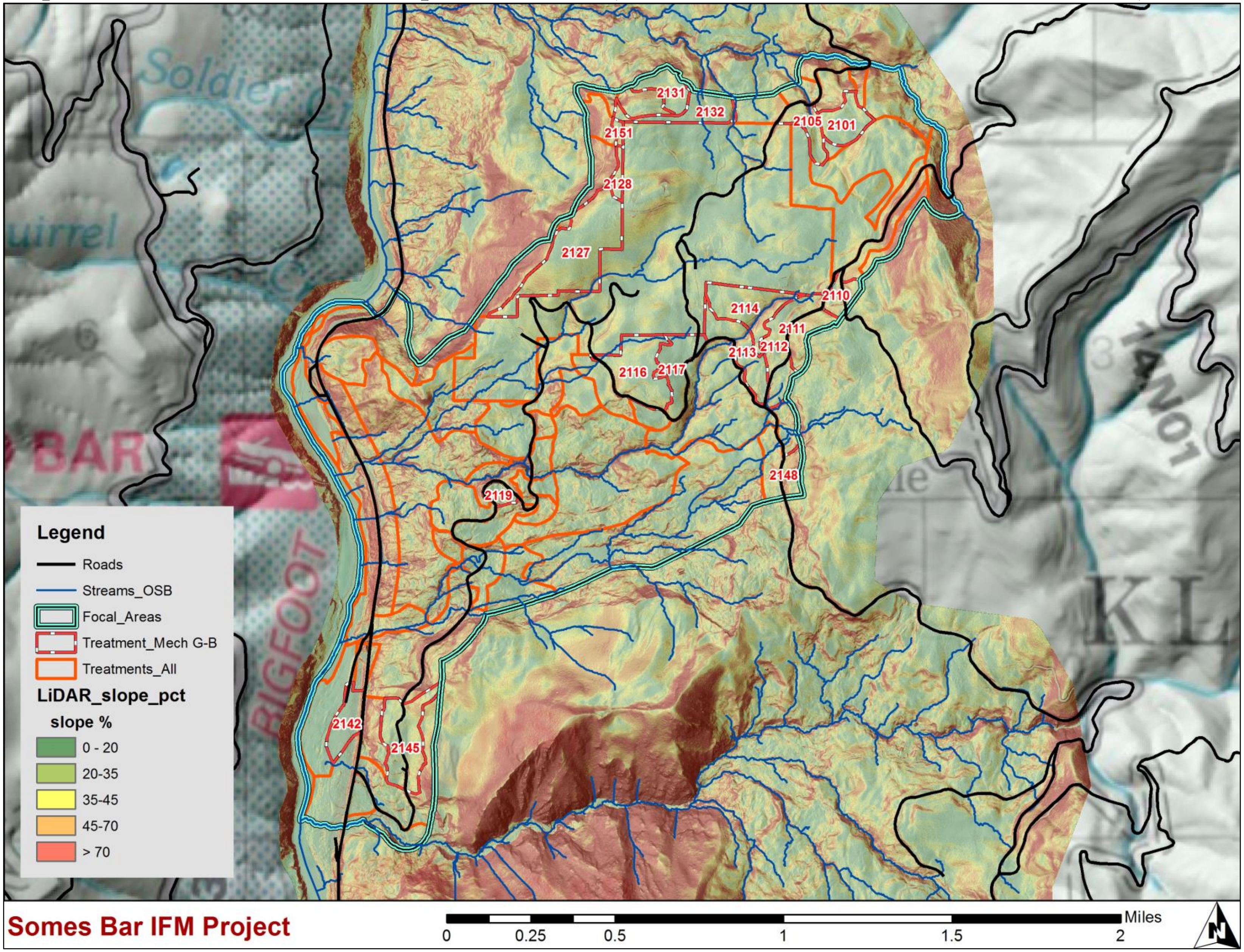
Area map of the Somes Bar Project Focal Areas along the mainstem Klamath River between Orleans and Happy Camp, CA.

Individual soil and slope maps follow below. These maps are not appropriate scale here to convey unit-level detail. Field-scale soil and slope maps were used for field reconnaissance, and can be produced for implementation purposes as necessary.

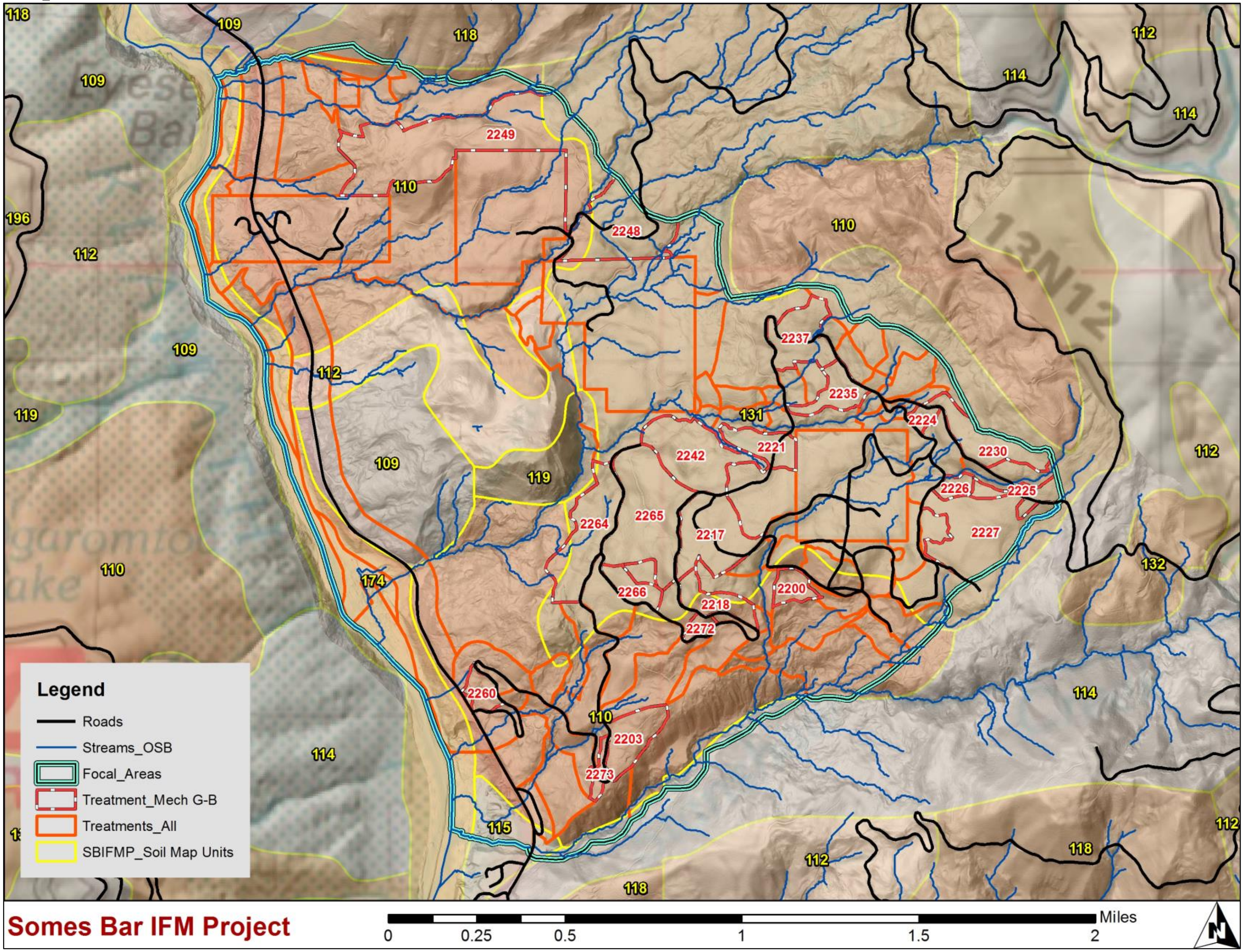
Map A1a. Ti Bar Focal Area – Soils (soils labeled in yellow; ground-based units labeled in red)



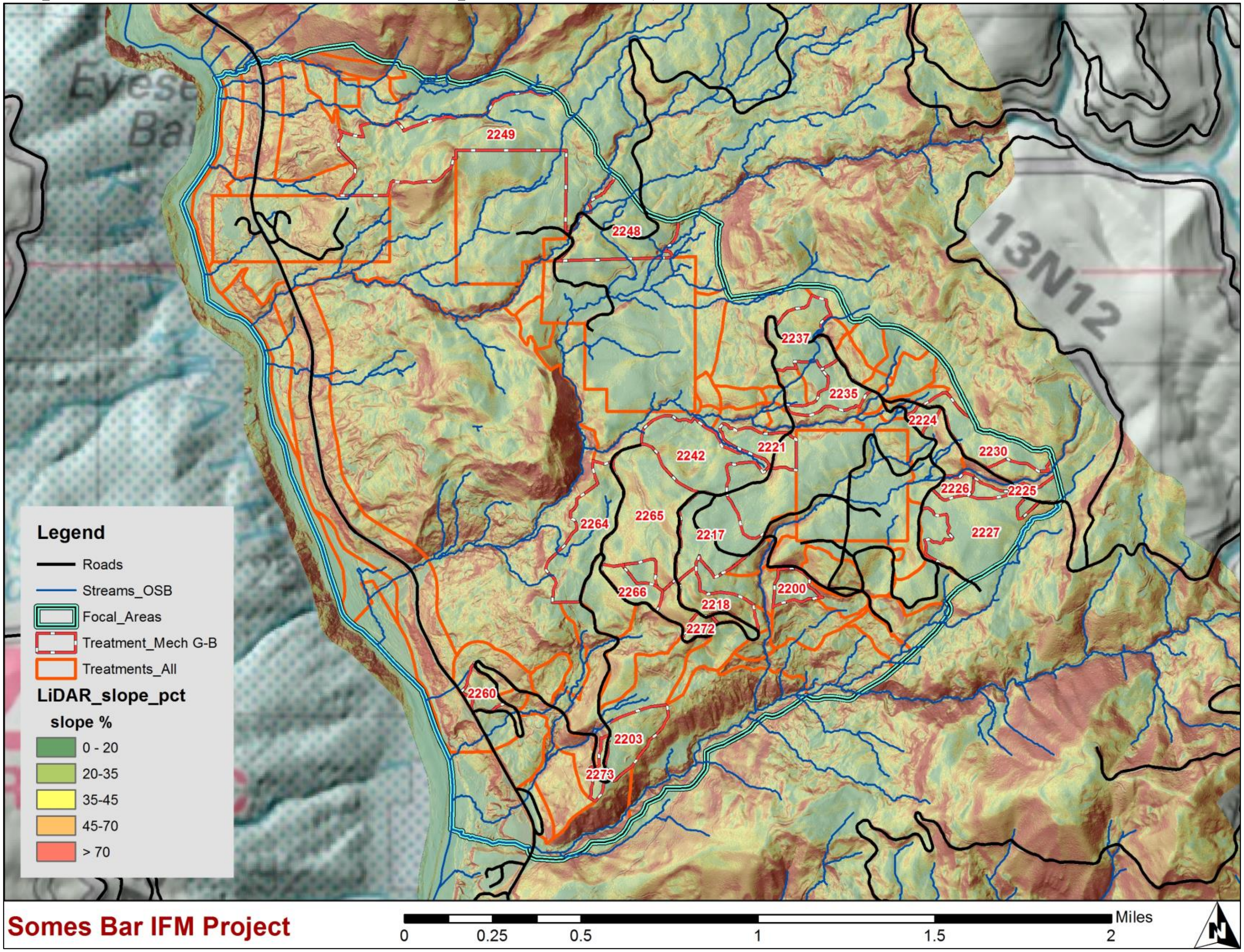
Map A1b. Ti Bar Focal Area – Slope % Gradient (LiDAR derived; ground-based units labeled in red)



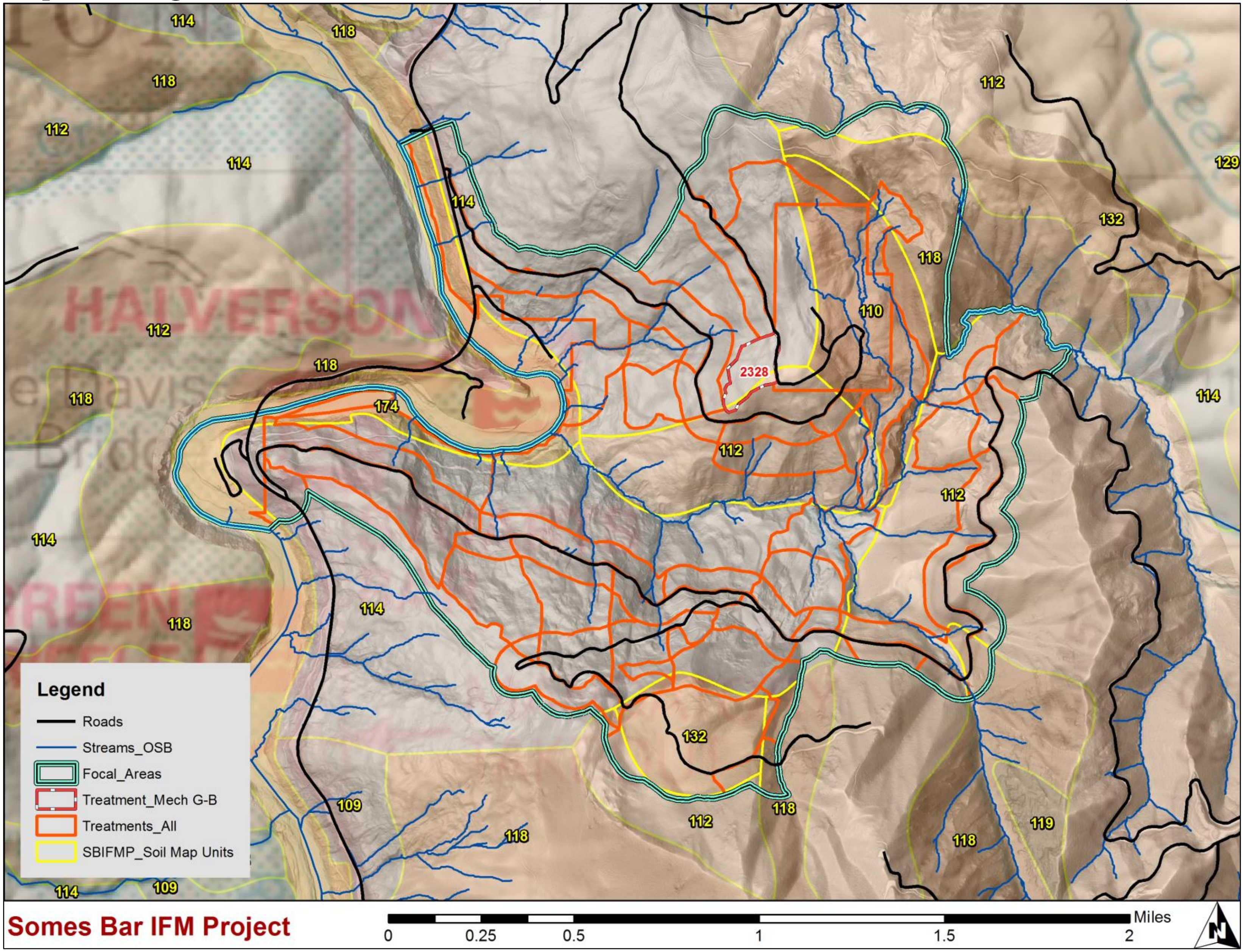
Map A2a. Patterson Focal Area – Soils (soils labeled in yellow; ground-based units labeled in red)



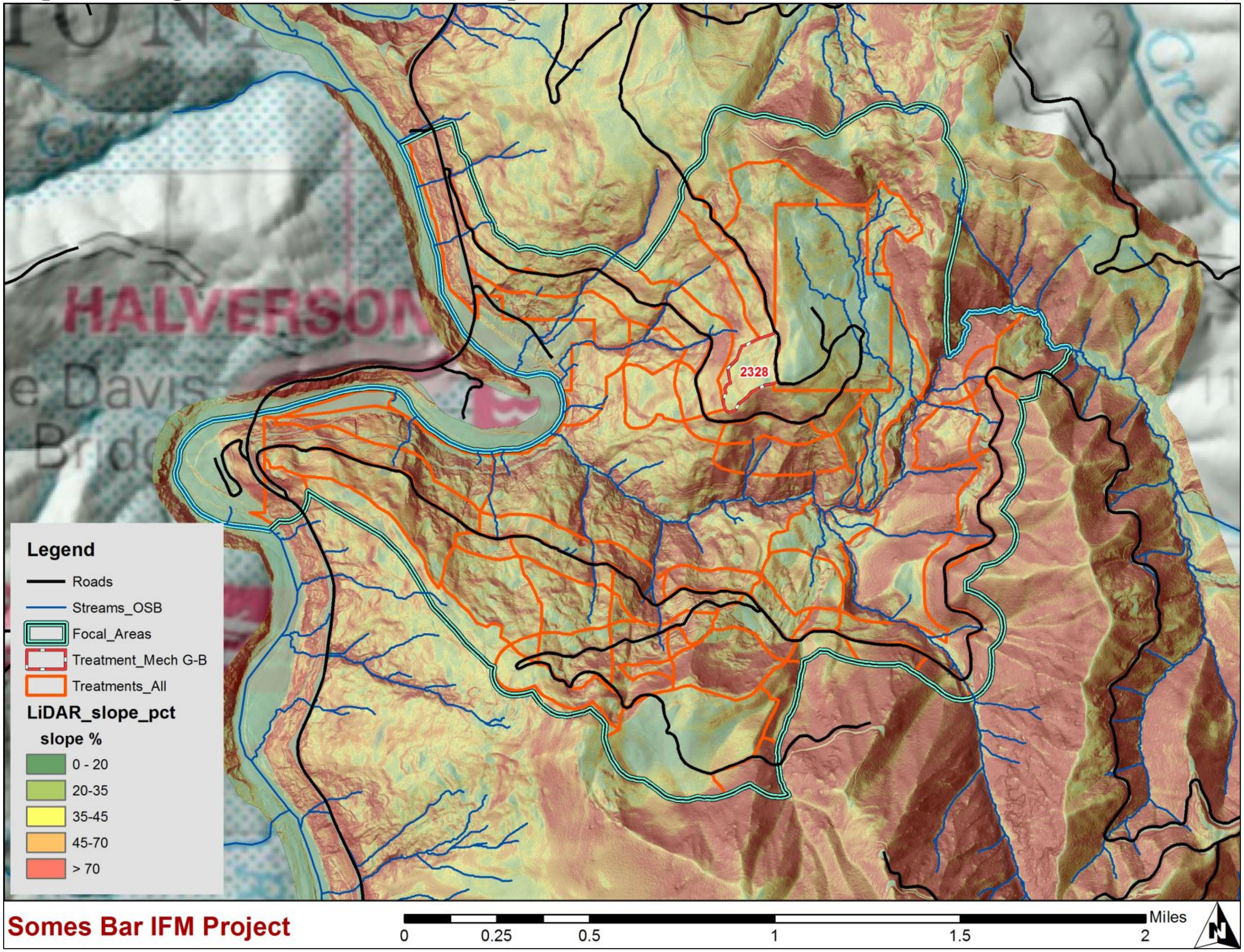
Map A2b. Patterson Focal Area – Slope % Gradient (LiDar derived; ground-based units labeled in red)



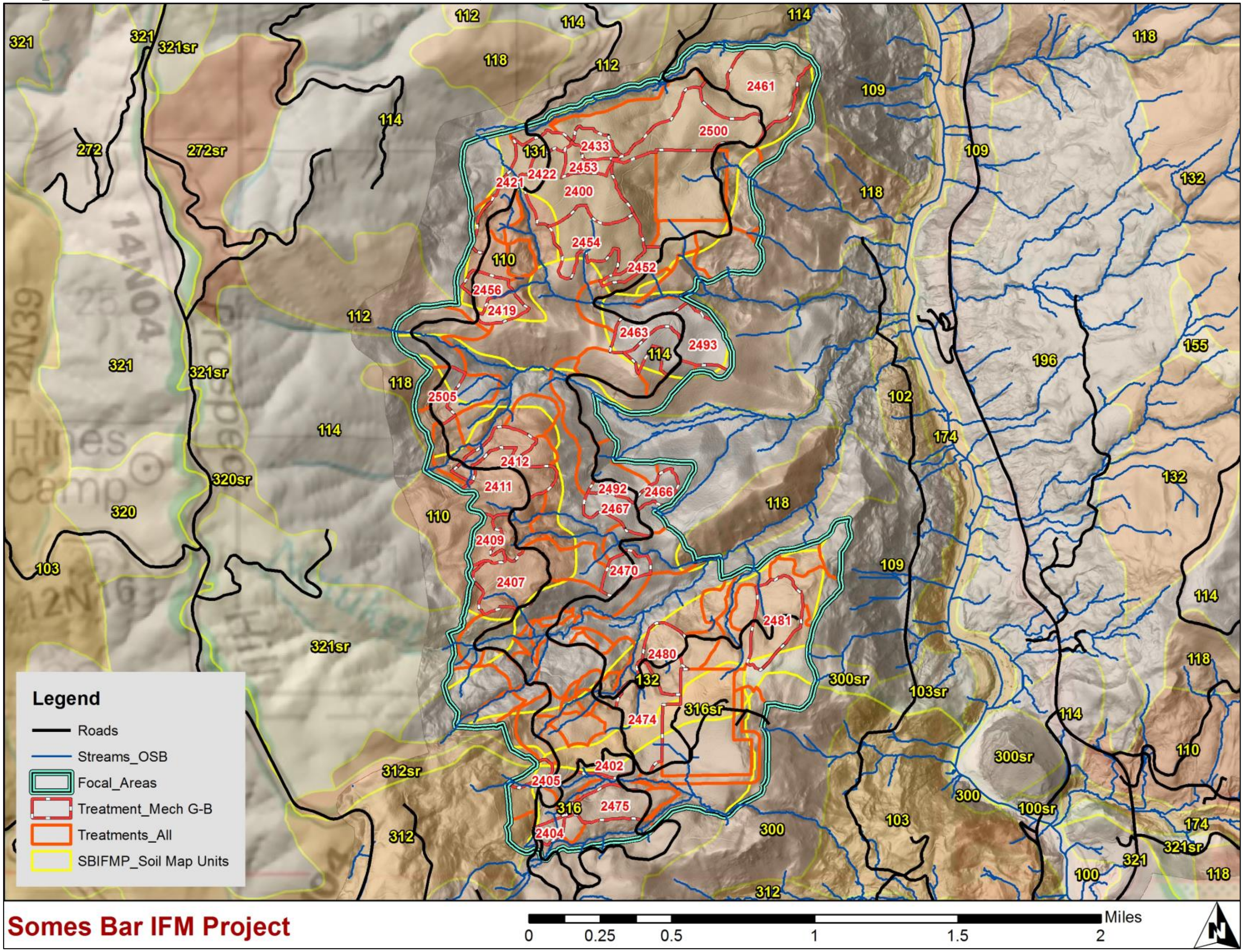
Map A3a. Rogers Creek Focal Area – Soils (soils labeled in yellow; ground-based units labeled in red)



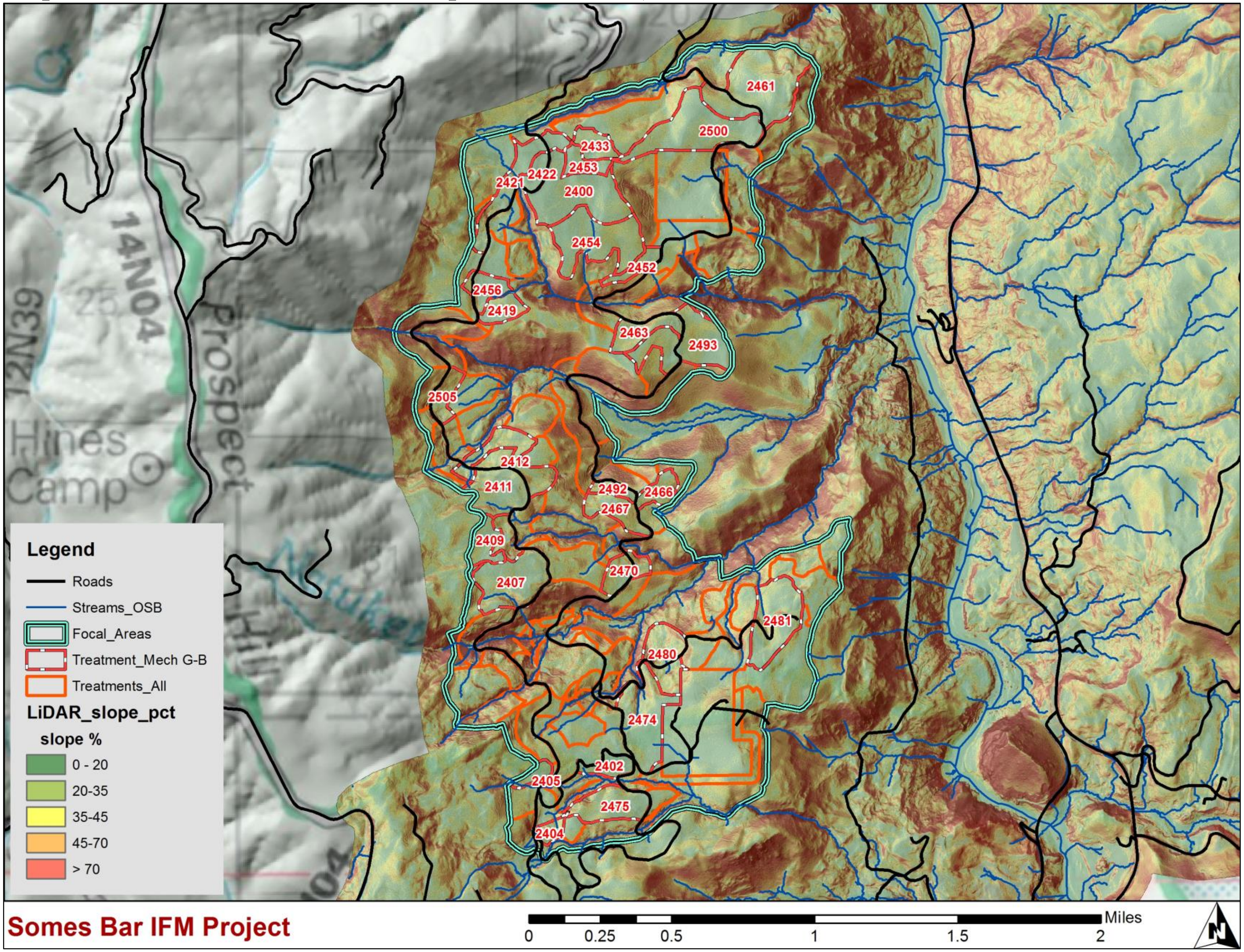
Map A3b. Rogers Creek Focal Area – Slope % Gradient (LiDAR derived; ground-based units labeled in red)



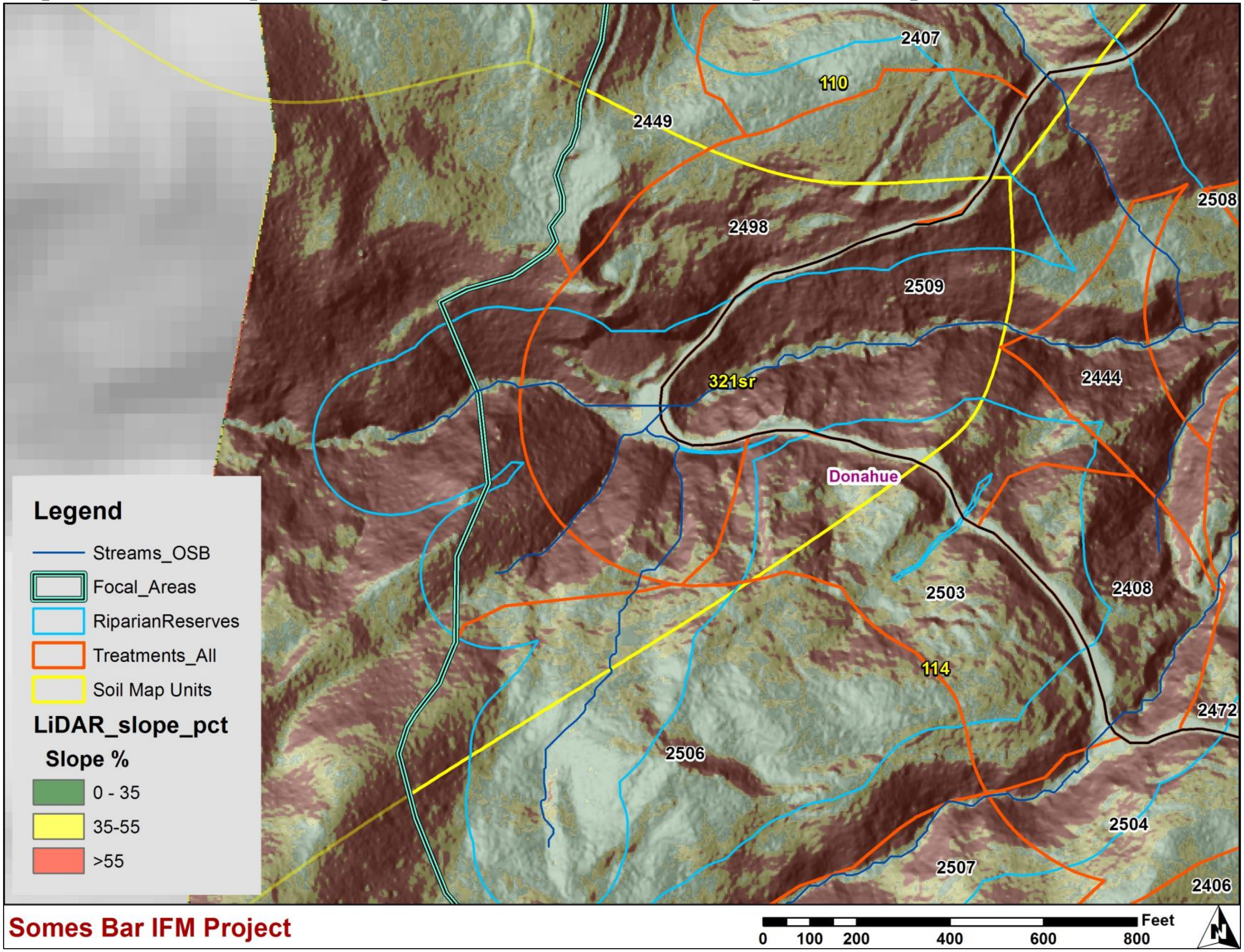
Map A4a. Donahue Focal Area – Soils (soils labeled in yellow; ground-based units labeled in red)



Map A4b. Donahue Focal Area – Slope % Gradient (LiDAR derived; ground-based units labeled in red)



Map A5. Donahue Special Mitigation Area: Soil 321sr with slopes >55% require 70-80% soil cover.



APPENDIX B – ACTIVITY UNIT BY SOIL MAP UNIT CROSSWALK

Table B1. Ti Bar Activity Units (units in **bold** are ground-based)

Unit ID	109	110	112	118	131	133	174	Total
2100		56.9			27.4			84.2
2101				2.0	7.7			9.7
2102				3.8	3.1			6.9
2103					4.5			4.5
2105					7.4			7.4
2107			1.2		2.1	1.4		4.8
2108			4.9		0.0			5.0
2110		5.7						5.7
2111		8.1						8.1
2112		13.8			2.6			16.5
2113		2.1			11.2			13.3
2114		0.2			16.2			16.4
2115					44.2			44.2
2116					19.6			19.6
2117					12.4			12.4
2118		14.0						14.0
2119		3.2						3.2
2120		5.9			0.2			6.1
2121		1.6			13.0			14.6
2122					7.7			7.7
2123		11.8						11.8
2124					4.0			4.0
2125		3.6						3.6
2126		7.9	12.4		1.9			22.2
2127			34.1		1.1			35.2
2128			2.5					2.5
2129		0.1	6.2					6.3
2130			4.6		2.2			6.8
2131		0.2	0.9		7.0			8.0
2132			2.0		9.2			11.2
2133		0.1	3.0					3.1
2134							12.2	12.2
2135			10.6				1.1	11.8
2136		62.9	18.2				0.2	81.3
2137		11.3	6.0				10.3	27.6
2138		3.7					2.7	6.3
2139	2.9		15.3				8.1	26.2
2140		0.0					20.8	20.8
2141							19.6	19.6
2142							9.0	9.0
2143	2.3			0.2			5.9	8.4
2144		16.0			57.0			73.0
2145		19.9		0.0				19.9
2146		27.2			6.2		7.1	40.4
2147			17.3					17.3
2148		5.0						5.0
2149		3.8			4.1			7.9
2150		2.6			0.3			2.9
2151			1.2					1.2
2152		10.9						10.9
2153					13.6			13.6
2154		2.8	5.9					8.8
2155					7.9			7.9
2156		3.8					4.7	8.5
2157					0.5			0.5
2158					2.8			2.8
2159				5.3	2.5			7.8
2160		9.8						9.8
2161		8.5			0.1			8.5
2162					9.2			9.2
2163		10.4		4.0			7.3	21.7
2164		3.7			1.8			5.5
2165							19.1	19.1
2166		1.5	2.6		31.4			35.5
2167					1.3			1.3
2168		3.6	3.8		1.0			8.4
2169		1.9			2.5			4.5
Total	5.2	344.6	152.7	15.3	346.7	1.4	128.1	994

Table B2. Patterson Activity Units (units in **bold** are ground-based)

Unit_ID	109	110	112	114	115	118	119	131	174	Total
2200		5.8								5.8
2201		9.2						2.9		12.1
2202		11.7								11.7
2203		13.4								13.4
2204		11.8		5.4	2.5					19.7
2205		15.1			0.0					15.1
2206		16.9						1.4		18.3
2207		3.3						8.7		12.0
2208		48.7		10.4						59.1
2209		31.3		0.2						31.5
2210		14.4								14.4
2211		10.6								10.6
2212		3.0						10.6		13.7
2213		7.4						2.7		10.1
2214		2.4						2.8		5.1
2215		3.4						7.5		10.9
2216								3.5		3.5
2217								24.2		24.2
2218		5.7						4.2		10.0
2219								4.3		4.3
2220								19.8		19.8
2221								10.1		10.1
2222								10.2		10.2
2223								6.7		6.7
2224								2.9		2.9
2225								7.3		7.3
2226								3.7		3.7
2227								33.3		33.3
2228								7.7		7.7
2229		1.6						10.7		12.3
2230								16.4		16.4
2231								1.4		1.4
2232								3.9		3.9
2233								8.4		8.4
2234								7.0		7.0
2235								9.5		9.5
2236								6.1		6.1
2237								17.2		17.2
2238		0.0						4.3		4.4
2239								2.7		2.7
2240		1.4						28.3		29.7
2241								2.0		2.0
2242								25.8		25.8
2243			6.5				3.2	18.2		27.9
2244			5.9							5.9
2245		3.6	1.9							5.6
2246								10.8		10.8
2247								14.0		14.0
2248		4.7						24.7		29.4
2249		66.8						11.5		78.4
2250		18.0								18.0
2251		6.0				1.3				7.2
2252		25.0						0.3		25.3
2253		55.7	3.5							59.3
2254		11.8								11.8
2255		23.8								23.8
2256		28.0								28.0
2257		8.0							2.0	10.0
2258		3.1							6.1	9.2
2259	26.9	33.1	11.2						32.8	104.0
2260		5.6								5.6
2261		5.4						0.8		6.2
2262		2.0								2.0
2263		16.8						4.3		21.1
2264		2.9					0.3	22.7		25.8
2265								39.6		39.6
2266								6.8		6.8
2267		2.1								2.1
2268	97.4	127.3	91.3				34.9	10.9		361.7
2269		5.1	0.2						12.8	18.1
2270									13.4	13.4
2271		7.3								7.3
2272		2.9								2.9
2273		3.4								3.4
2274		2.0							7.6	9.6
2275		2.7								2.7
2276								4.2		4.2
2277								3.2		3.2
2278								4.9		4.9
2279								3.9		3.9
2280								2.6		2.6
2281								4.4		4.4
2282		3.6								3.6
2283								3.0		3.0
2284		17.4								17.4
2285		5.0			0.9					5.9
2286		7.0								7.0
2287		4.8								4.8
2288		12.0								12.0
2289		1.6								1.6
2290								20.4		20.4
2291								9.6		9.6
2292								1.6		1.6
2293		13.2								13.2
2294		1.2						3.8		5.0
2295								4.4		4.4
2296								6.3		6.3
Total	124.3	756.0	120.6	16.0	3.4	1.3	38.4	555.1	74.6	1,690

Table B3. Rogers Creek Activity Units (units in **bold** are ground-based)

Unit_ID	110	112	114	118	132	174	Total
2300		5.8	0.5	1.1	54.0		61.4
2301		14.6		0.0			14.6
2302		4.5					4.5
2303			36.2				36.2
2304			28.3				28.3
2305			5.4				5.4
2306			19.2				19.2
2307			10.5				10.5
2308			19.9		2.2		22.1
2309			14.1				14.1
2310			21.3		3.5		24.9
2311		1.2		4.8	4.6		10.6
2312		1.5	4.9				6.4
2313		5.3		0.1			5.4
2314		36.0	0.7	3.2			39.8
2315		14.8		0.8			15.6
2316		4.2					4.2
2317	0.0	15.4					15.4
2318		7.0					7.0
2319			17.7				17.7
2320			3.8				3.8
2321			9.5				9.5
2322			32.6				32.6
2323		0.1	47.4				47.4
2324			4.3			14.6	18.9
2325			12.5			2.4	14.9
2326			13.9				13.9
2327			5.2				5.2
2328		1.5	10.2				11.7
2329	0.1	13.6	0.0				13.7
2330		9.8					9.8
2331	0.6	5.7					6.3
2332	1.5	4.1					5.6
2333	19.8	5.6	0.1				25.5
2334	5.5			6.3			11.8
2335	4.0		26.1				30.1
2336			16.8				16.8
2337			9.2			0.6	9.8
2338		0.8	30.5				31.3
2339		63.5	101.3			7.4	172.3
2340	21.8	16.9	27.3	63.3	0.1		129.5
2341			29.9				29.9
2342	10.1	55.8	6.2	0.0			72.1
2343		0.9	17.9				18.7
2344		18.9					18.9
2345		3.1	0.1				3.2
2346			16.5				16.5
2347			2.3				2.3
2348		0.9	15.9		0.3		17.1
2349			1.9				1.9
2350			2.9		0.1		3.0
2351			2.2				2.2
2352			10.3				10.3
2353			4.3	4.6	0.0		8.9
2354			20.2			0.0	20.2
2355		7.1					7.1
2356		32.9		5.3			38.2
2357			20.6			9.7	30.3
2358			24.4			0.4	24.8
2359						6.0	6.0
2360			6.8				6.8
2361			20.8				20.8
Total	63.3	351.3	732.8	89.6	64.9	41.1	1,343

Table B4. Donahue Activity Units (units in **bold** are ground-based)

ID_No	109	110	112	114	118	131	132	300sr	312sr	316sr	321sr	Total
2400		4.1				30.2						34.3
2401				1.8								1.8
2402										**7.2**		7.2
2403										8.9		8.9
2404									0.0	**4.3**		4.3
2405									2.1	**2.3**		4.4
2406				2.6			8.2		1.0	0.8		12.5
2407		25.6		0.4								26.0
2408				3.9								3.9
2409		9.0										9.0
2410		8.9										8.9
2411		23.5										23.5
2412		18.9										18.9
2413		5.7		0.1								5.8
2414		3.4			3.2							6.6
2415				8.6	2.0							10.6
2416				0.6	5.5							6.1
2417			16.9	11.4	1.1							29.4
2418		3.5	2.9	2.5								9.0
2419		5.8	2.0									7.8
2420		7.0										7.0
2421		8.2		0.0		10.9						19.1
2422						5.4						5.4
2423		6.1										6.1
2424		0.7		1.3								2.0
2425		9.0		8.0								17.0
2426		1.6			4.0							5.6
2427							9.5			12.5		22.0
2428				1.7			1.2					3.0
2429				1.0								1.0
2430			2.5	11.6		3.3						17.4
2431			0.8			15.4						16.2
2432			9.4	3.4		0.5						13.3
2433						8.0						8.0
2434			0.5			4.9						5.4
2435			1.4			11.6						13.0
2436				0.3			3.3		1.4			5.1
2437		8.0		4.4								12.4
2438					3.3							3.3
2439						20.4						20.4
2440		0.5		17.3		4.4						22.2
2441							9.5					9.5
2443		40.4	60.8	49.2	5.8	4.4						160.6
2444				2.9								2.9
2445				0.5			1.8					2.3
2446				36.8	1.1		13.4					51.4
2447				2.8			8.2					11.0
2448										16.2		16.2
2449		3.9									1.4	5.3
2450				4.8								4.8
2451			0.8	1.3								2.2
2452			0.1			6.0						6.1
2453						6.9						6.9
2454		0.9	2.1			27.7						30.7
2455		6.3										6.3
2456		8.4	0.2	0.1								8.7
2457		7.4										7.4
2458			6.8	2.1		2.5						11.4
2459			17.3			2.4						19.7
2460			12.2			8.1						20.4
2461	0.1					44.1						44.1
2462			10.6	14.8								25.5
2463			0.2	11.0								11.2
2464			15.8	0.5								16.3
2465				10.2								10.2
2466				7.5								7.5
2467				11.4								11.4
2468				4.6								4.6
2469				12.9	2.9							15.9
2470				10.2								10.2
2471				5.4								5.4
2472				23.6			2.5					26.1
2473				0.4			7.2					7.6
2474							**16.4**			**12.3**		28.7
2475										**17.2**		17.2
2476										4.0		4.0
2477										3.4		3.4
2478									5.9	1.0		6.9
2479						31.4						31.4
2480				0.2			**17.3**					17.5
2481							**24.5**	1.5				25.9
2482				2.5			0.2					2.7
2483										3.4		3.4
2484							9.0					9.0
2485							8.5	0.0		1.2		9.7
2486	0.3						4.5	24.0		1.5		30.2
2487							7.1					7.1
2488				0.9			5.6					6.5
2489	0.0			1.9			5.0					6.9
2490	4.4			0.1			10.4					14.9
2491	8.1			0.6			0.1					8.8
2492				4.3								4.3
2493			1.3	28.0								29.3
2494			3.0	3.0								6.0
2495	0.9		7.0			9.2						17.1
2496						15.1						15.1
2497										2.9		2.9
2498		2.5									8.3	10.8
2499			1.8	17.2								19.0
2500						34.9						34.9
2501				4.7								4.7
2502									6.8	5.9		12.7
2503				5.1							1.8	6.9
2504				3.6								3.6
2505				2.5	5.1							7.7
2506				15.6							2.9	18.5
2507				6.8			2.2					9.0
2508				2.2								2.2
2509		1.3		38.0							6.4	45.7
2510								2.6		12.2		14.9
Total	13.8	220.5	176.6	431.7	34.2	307.7	175.5	28.1	17.2	117.3	20.7	1,543

APPENDIX C – EROSION HAZARD RATING CALCULATIONS

Soil Map Unit Soil Burn Severity	Texture	Aggreate Adjustment	Erodibility	Climate (2.0 in) 3	Water Movement	Runoff	Uniform Slope length	Runoff Production	Runoff Production Rating	Slope %	Runoff Energy Rating	Soil Cover %	Soil Cover Rating	Erosion Hazard Rating	Erosion Hazard Rating
109	**Clallam deep, 15-70% slopes**														
Current	3	-1	2	3	3	0	6	12	4.00	42	0.42	> 90	0.5	**2**	L
Post-Treatment	3	-1	2	3	3	0	6	12	4.00	42	0.42	51-70	2	**7**	M
Bare	3	-1	2	3	3	2	6	14	4.67	42	0.42	< 10	3	**12**	M
110	**Clallam very deep, 9-70% slopes**														
Current	3	0	3	3	1	0	6	10	3.33	39	0.39	> 90	0.5	**2**	L
Post-Treatment	3	0	3	3	1	0	6	10	3.33	39	0.39	51-70	2	**8**	M
Bare	3	0	3	3	1	2	6	12	4.00	39	0.39	< 10	3	**14**	H
112	**Clallam deep-Deadwood assoc, 50-90% slopes**														
Current	3	-1	2	3	3	0	6	12	4.00	52	0.52	> 90	0.5	**2**	L
Post-Treatment	3	-1	2	3	3	0	6	12	4.00	52	0.52	51-70	2	**8**	M
Bare	3	-1	2	3	3	2	6	14	4.67	52	0.52	< 10	3	**15**	H
114	**Clallam deep-Goldridge gravelly assoc, 30-90% slopes**														
Current	3	-1	2	3	3	0	6	12	4.00	48	0.48	> 90	0.5	**2**	L
Post-Treatment	3	-1	2	3	3	0	6	12	4.00	48	0.48	51-70	2	**8**	M
Bare	3	-1	2	3	3	2	6	14	4.67	48	0.48	< 10	3	**13**	H
115	**Clallam very deep-Riverwash assoc, 0-15% slopes**														
Current	3	0	3	3	1	0	6	10	3.33	44	0.44	> 90	0.5	**2**	L
Post-Treatment	3	0	3	3	1	0	6	10	3.33	44	0.44	51-70	2	**9**	M
Bare	3	0	3	3	1	2	6	12	4.00	44	0.44	< 10	3	**16**	H
118	**Deadwood-Clallam deep assoc, 50-90% slopes**														
Current	3	-1	2	3	4	0	6	13	4.33	50	0.50	> 90	0.5	**2**	L
Post-Treatment	3	-1	2	3	4	0	6	13	4.33	50	0.50	51-70	2	**9**	M
Bare	3	-1	2	3	4	2	6	15	5.00	50	0.50	< 10	3	**15**	H
119	**Deadwood-Rock Outcrop assoc, 50-90% slopes**														
Current	3	-1	2	3	4	2	6	15	5.00	47	0.47	> 90	0.5	**2**	L
Post-Treatment	3	-1	2	3	4	2	6	15	5.00	47	0.47	51-70	2	**9**	M
Bare	3	-1	2	3	4	5	6	18	6.00	47	0.47	< 10	3	**17**	H
131	**Goldridge gravelly, 15-50% slopes**														
Current	3	-1	2	3	3	0	6	12	4.00	34	0.34	> 90	0.5	**1**	L
Post-Treatment	3	-1	2	3	3	0	6	12	4.00	34	0.34	51-70	2	**5**	M
Bare	3	-1	2	3	3	2	6	14	4.67	34	0.34	< 10	3	**9**	M
132	**Goldridge gravelly-Clallam deep-Prather assoc, 30-70% slopes**														
Current	3	-1	2	3	3	0	6	12	4.00	42	0.42	> 90	0.5	**2**	L
Post-Treatment	3	-1	2	3	3	0	6	12	4.00	42	0.42	51-70	2	**7**	M
Bare	3	-1	2	3	3	2	6	14	4.67	42	0.42	< 10	3	**12**	M
133	**Goldridge-Gilligan assoc, 15-90% slopes**														
Current	3	0	3	3	3	0	6	12	4.00	64	0.64	> 90	0.5	**4**	L
Post-Treatment	3	0	3	3	3	0	6	12	4.00	64	0.64	51-70	2	**15**	H
Bare	3	0	3	3	3	2	6	14	4.67	64	0.64	< 10	3	**27**	H
174	**Riverwash deposits**														
Current	3	-1	2	3	1	0	6	10	3.33	37	0.37	> 90	0.5	**1**	L
Post-Treatment	3	-1	2	3	1	0	6	10	3.33	37	0.37	51-70	2	**5**	M
Bare	3	-1	2	3	1	2	6	12	4.00	37	0.37	< 10	3	**9**	M
300sr	**Rock Outcrop-Lithic Xerorthents complex, metaigneous, 60-90% slopes**														
Current	3	-1	2	3	6	2	6	17	5.67	28	0.28	> 90	1	**3**	L
Post-Treatment	3	-1	2	3	6	2	6	17	5.67	28	0.28	51-70	2	**6**	M
Bare	3	-1	2	3	6	5	6	20	6.67	28	0.28	< 10	3	**11**	M
312sr	**Holland deep, 30-50% slopes**														
Current	3	-1	2	3	3	0	6	12	4.00	36	0.36	> 90	0.5	**1**	L
Post-Treatment	3	-1	2	3	3	0	6	12	4.00	36	0.36	51-70	2	**6**	M
Bare	3	-1	2	3	3	2	6	14	4.67	36	0.36	< 10	3	**10**	M
316sr	**Aiken-Holland complex, deep, 10-40% slopes**														
Current	3	0	3	3	3	0	6	12	4.00	28	0.28	> 90	0.5	**2**	L
Post-Treatment	3	0	3	3	3	0	6	12	4.00	28	0.28	51-70	2	**7**	M
Bare	3	0	3	3	3	2	6	14	4.67	28	0.28	< 10	3	**12**	M
321sr	**Hugo mod-deep-Maymen complex, 50-70% slope**														
Current	3	0	3	3	2	0	6	11	3.67	58	0.58	> 90	0.5	**3**	L
Post-Treatment	3	0	3	3	2	0	6	11	3.67	58	0.58	51-70	2	**13**	H
Bare	3	0	3	3	2	2	6	13	4.33	58	0.58	< 10	3	**23**	H

NOTE: GIS-derived slope gradients (weighted average, %); Soil cover ratings for "post-project" and "bare" assume residual 50-70% tree canopy cover.